Section 11
Nature and Extent of Biota Contamination

11.1 Introduction

Tissue samples were collected and analyzed for chemical characterization to complete human health and ecological risk evaluations. The resulting data were used to assess risks to fish and wildlife resources and to human health. These sample data will also support the feasibility study and potential future remedial actions. Due to the migratory nature of certain types of biota collected, this section is outlined by group (of biota type) and by AOC for sedentary species only (as described in the Phase II SAP) but not by energy area as discussed in previous sections. The three areas in the estuary are Upper Calcasieu, Bayou d'Inde, and Lower Calcasieu and the reference area.

11.1.1 Tissue Design Strategy

An ecological site reconnaissance-sampling program of fish and invertebrate tissues was conducted in spring 2000 (Phase I). This sampling program included a number of fish and invertebrate species, including a few large, predatory fish species that in some cases dominated the data set (e.g., black drum). Samples were taken from a number of sub-areas within Bayou d'Inde, Upper Calcasieu, and Lower Calcasieu and the reference area. Each sample was analyzed for a broad suite of metals and organic parameters, and a subset of samples was also analyzed for dioxins and furans. For some organic parameters (e.g., individual aroclors), the detection limits were orders of magnitude above levels associated with effects to wildlife (Moore et al. 1999). Thus, the Phase II sampling program was implemented throughout 2001 and served two purposes: (1) the data were used in a screening level ecological risk assessment (SERA) to update which chemicals and locations potentially pose risks to the wildlife, based on assessment endpoints identified at the BERA workshop (MacDonald et al. 2000), and (2) the data on chemical levels in fish and invertebrate tissues were used as inputs to wildlife exposure models in the BERA and for human health risk assessment.

The following ecosystem objectives were established at the BERA workshop (MacDonald et al. 2000) that had direct relevance to the design of the Phase II sampling program:

- Maintain and, if necessary, restore aquatic environmental conditions that will support an abundant and diverse fish community
- Maintain and, if necessary, restore aquatic, wetland, and terrestrial habitats that will support abundant, diverse, and self-sustaining populations of aquatic-dependent birds
- Maintain and, if necessary, restore aquatic, wetland, and terrestrial habitats that will support abundant, diverse, and self-sustaining populations of aquatic dependent mammals

The fish and wildlife species that were the focus of the Phase II sampling program range from relatively small predators with limited foraging ranges (e.g., kingfishers) to large predators with broad foraging ranges (e.g., black drum, dolphins). Several wildlife focal species are also highly opportunistic feeders (e.g., raccoons, mink). Potential prey species are highly variable in terms of their preferred habitat (e.g., sheltered bayous versus open water), size, mobility, and foraging range. The point estimates or distributions that were developed in the BERA for prey tissue concentrations in the wildlife exposure models need to be appropriately scaled. For example, kingfishers have small foraging ranges and feed on small fish, which themselves have small ranges. The prey of the kingfisher exhibit high spatial variability in tissue residues depending on proximity to a contaminant source. Since neither the kingfisher nor their prey spatially averages their exposures over a wide range, separate exposure analysis was required for kingfishers inhabiting different sub-areas in the Calcasieu Estuary. Conversely, for wildlife species that forage widely (e.g., dolphins) on prey that spatially average their exposures (e.g., black drum), a single exposure analysis for the estuary was considered appropriate. These two examples required different Phase II sampling designs. For kingfishers, it was necessary to sample small fish from a number of locations using a "randomized block" design in which samples are randomly chosen from each of the sub-areas, with the size of the sub-area scaled approximately to the foraging range of the kingfishers. For dolphins, it was necessary to randomly sample large fish from the entire estuary.

Two approaches were used to develop the Phase II sampling design. First, the feeding ecology of the fish and wildlife focal species was assessed, and second, likely prey species (or types) were identified and their likely foraging areas were estimated. A statistical analysis was conducted on the tissue residue data collected during the Phase I sampling program. The objective of these analyses was to determine numbers of samples in need of collection during Phase II to reliably develop measures of centrality and variability over spatial scales of interest for the different predator-prey combinations. The statistical analyses, however, were limited since the Phase I data set were dominated by non-detects as a result of high detection limits for many of the organic chemicals (e.g., aroclors, dioxins, and furans). Also, the Phase I data set has insufficient sample sizes for invertebrates and small fish species to permit useful statistical analysis. The Phase II design combined these two approaches for the sampling program in the Calcasieu Estuary.

11.1.1.1 Prey Sampling Strategy

The selected prey species were organized into four logical groups. Each group reflects a particular combination of size range, pelagic versus demersal distribution in the water column, trophic level, and foraging range. The sorting criteria and the resulting prey groups are discussed below. The grouped prey species are presented in Exhibit 11-1.

Body Size

Fish and invertebrate species found in the southern United States of America (USA) vary widely in terms of body size. Body sizes range from tiny gobies (Gobiidae) less

than 1 cm in length to alligator gars that can reach nearly 3 m in length. Most fish local to the estuary, however, are approximately ¼ to ½ m in length.

Water Column Distribution

The estuarine habitat found in Southern Louisiana favors demersal fish. Tidal, coastal, swampy, or marshy areas tend to be shallow and have mostly muddy bottoms that provide a good substrate and food source for demersal fish prey items such as crustaceans, annelids, mollusks, and algae. The majority of fish species listed for this geographic location are bottom fish. Examples include catfishes (ictaluridae), blennies (Bleniidae), suckers (Castomidae), some killifish (Fundulidae), gobies, wormfishes (Microdesmidae), flounders (all families), and rockfishes (Sebastidae).

Pelagic fish include silversides (Atherinidae), sunfishes (Centrachidae), herrings (Clueidae), pupfishes (Cyprinodontidae), anchovies (Engraulidae), killifishes, gars (Lepisosteidae), mullets (Muglidae), poecilids (Poecilidae), and drums (Sciaenidae).

Trophic Level

The trophic level occupied by an organism is related to the amount of energy, in terms of food, required by the organism. Organisms capable of utilizing inorganic chemicals, e.g., plants or food of low energy content, are considered to be on a lower trophic level, whereas, for example, predatory species requiring food of high-energy content are considered to be on a higher trophic level. The trophic level number indicates the level of the organism in the food chain (World Health Organization [WHO] 1989).

The selected set of fish and invertebrate species includes a combination of feeding strategies and prey or food items. This had the effect of giving a wide range of trophic level values. Prey species at different trophic levels are likely to have substantially different levels of bioaccumulative chemicals in their tissues. There are prey species that are exclusively phytoplanktivores such as herring, shad, sardine, and menhaden (Clupeidae). There are also purely carnivorous species such as blue crab, bass (Centrarchidae), anchovy, gar (Lepisosteidae), and most sebastids (Sebastidae). Most of the reported species, however, are omnivores.

The trophic level for planktivores is low and is set at 2.0. For omnivores, numeric trophic levels ranged from 2.1 for mullets to 3.4 for silversides (Atherinidae) and pupfishes. Carnivores occupy even higher trophic levels.

Foraging Range

The foraging range of each prey species is a combination of foraging strategy, diet requirements, and body size. A general observation is that larger fish tend to travel more than smaller fish, crabs, and clams. The latter group tends to find suitable habitat in quiet bays and inlets and remains there, whereas larger fish are more likely to enter open water and travel extensively in search of food. There are exceptions to this observation. Anchovies, for example, tend to be small yet cover large distances. On the other hand, gars can be very large yet tend to move little. Species with large foraging

ranges are likely to exhibit less spatial variation in tissue residues than will species with small foraging ranges.

Prey Groups
Exhibit 11-1 below represents the five groups of prey species likely to occur in the Calcasieu Estuary. Species within a particular group are interchangeable since predators will be unlikely to have distinct preferences for one species over another within a group.

Exhibit 11-1 Prey Groups of the Calcasieu Estuary

Group 1	Small bentho-pelagic fish and small benthic invertebrates that inhabit shallow water and have a localized distribution. The trophic level ranges from 2 to 2.5. Tissue residue levels were expected to vary substantially depending on proximity to contaminant sources.
Group 2	Small to large pelagic fish that inhabit water of any depth and have a broad distribution. The trophic level ranges from 2 to 2.5. Tissue residue levels were not expected to vary widely between sub-areas in the Calcasieu Estuary.
Group 3	Medium pelagic fish that inhabit water of any depth and have a broad foraging range. The trophic level ranges from 2 to 2.5. Tissue residue levels were not expected to vary widely between sub-areas in the Calcasieu Estuary.
Group 4	Medium to large bento-pelagic fish that inhabit water of any depth and have a broad foraging range. The trophic level ranges from 2.5 to 3.5. Tissue residue levels were expected to be quite high for bioaccumulative chemicals but were unlikely to vary widely between sub-areas in the Calcasieu Estuary.
Group 5	Large pelagic fish that inhabit shallow water and have a local distribution. The trophic levels were expected to be quite high for bioaccumulative chemicals in contaminated sub-areas in the Calcasieu Estuary. Otherwise, trophic levels would be lower.

Each of the fish and wildlife focal species for the estuary tend to feed upon one, or at most, two of the above prey groups. The majority of fish and wildlife focal species feed upon prey Group 1, although several species also feed upon prey in Groups 2, 3, and/or 4.

11.1.1.2 Sample Size Rationale

The sample size for the Phase II tissue sampling was based upon the following:

- Sampling of small fish and invertebrates with more limited mobility (i.e., Group 1) was a crucial component to develop credible exposure estimates for most of the fish and wildlife focal species for the ecological risk assessment. These species exhibit considerable spatial variation across the Calcasieu Estuary; therefore, obtaining sufficient sample numbers from each of the sub-areas was critical. The results of this sampling permitted development of separate exposure estimates in different sub-areas for individuals of focal species with small foraging ranges (e.g., kingfishers).

- Sampling of fish species with a greater tendency to forage over a wider range (i.e., Groups 2 through 4) was also required for some wildlife focal species (e.g., osprey and dolphin). These species exhibit less spatial variation across the Calcasieu Estuary, and, thus, the sampling program would not require as detailed sampling at the sub-area spatial scale. For these groups, it was adequate to obtain samples at a

higher level of resolution (e.g., Upper Calcasieu, Lower Calcasieu, Bayou d'Inde) for both ecological and human health risk assessment.

- No sampling of Group 5 fish species (i.e., gar) was required for the ecological risk assessment.

- Sampling from Groups 4 and 5 (fillets only) was necessary only for human health risk assessment.

11.1.1.3 Sample Collection

Sampling locations for tissue collection were predetermined based on the randomly generated Triad locations (Figure 4-7). At each of the sampling stations, multiple samples of Group 1 fish and invertebrates (i.e., three to five samples of each subgroup) were collected within a 100-m radius of the designated coordinates. The dimensions of each sampling station were expanded to 500-m for collecting Groups 2, 3, and 4 fish samples. The coordinates of alternate sampling stations were also identified if the primary sampling station did not yield sufficient samples.

11.1.2 Biota Tissue Sample Analytical Protocol

Biota tissue samples collected from the Calcasieu Estuary and the reference area were analyzed off site. A subcontract laboratory and/or a PRP laboratory were used to analyze for chemicals of interest. The analytical protocol included TAL metals, SVOCs, PCBs, PCB congeners, pesticides, and dioxin/furans. Dioxin/furans and PCB congeners analyses were limited to 20 percent of the total biota samples collected. Analytical protocols included EPA SW-846 (EPA 1997a) and USGS and EPA CLP standard methods.

Exhibit 11-2 Description of Groups for the Calcasieu Estuary

Type	Group	Description of Group	Size Class (cm)
Fish	1	Small sedentary species – low trophic level (<2.5)	<15 cm
Invertebrates	1A	Small sedentary bivalves	<7.5 cm
Invertebrates	1B	Small sedentary crustaceans	<7.5 cm
Invertebrates	2A	Small migratory crustaceans	<12.5 cm
Invertebrates	2B	Large migratory crustaceans	>12.5 cm
Fish	2A	Small migratory species - low trophic level (<2.5)	<15 cm
Fish	2B	Small migratory species - high trophic level (>2.5)	<15 cm
Fish	3A	Medium migratory species - low trophic level (<2.5)	15 to <30 cm
Fish	3B	Medium migratory species - high trophic level (>2.5)	15 to <30 cm
Fish	4A	Large migratory species - low trophic level (>2.5)	30 to 90 cm
Fish	4B	Large migratory species - high trophic level (>2.5)	30 to 90 cm

Biota tissue sample results were segregated into different groups based on the aforementioned criteria. Results evaluation is presented in Exhibit 11-2 according to group criteria. Numbers of samples collected from each group are presented in Exhibit 11-3.

Exhibit 11-3 Number of Samples Collected per Group

Group	Tissue Type	No. Of Samples Collected
1	Whole body	159
1A	Shellfish	45
1B	Shellfish	9
2A	Shellfish	75
2A	Whole body	47
2B	Shellfish	30
2B	Whole body	28
3A	Whole body	66
3B	Fish Fillet	19
3B	Whole body	126
4A	Whole body	57
4B	Fish Fillet	104
4B	Whole body	73

11.2 Biota Tissue – Nature and Extent of Contamination

The tissue-sampling program in the reference area, Upper Calcasieu, Lower Calcasieu, and Bayou d'Inde included the collection and analysis of fish and invertebrate samples for a combination of compounds in accordance with EPA SW-846 and USGS and EPA CLP standard methods. The compounds of interest included SVOCs, pesticides, PCBs, PCB congeners, dioxin/furans, and metals.

This section describes the extent to which these compounds exceeded analytical detection limits. Comparisons of analytical results between the reference area and AOCs are also presented. These comparisons are based on geometric mean concentrations of COPCs in biological tissue. Data tables identifying detected analytes are presented in Appendix H.

11.2.1 Nature and Extent of Tissue Contamination

This section describes the analytes detected for all Groups 1, 2, 3, and 4 tissue samples collected throughout the estuary.

11.2.1.1 Shellfish

11.2.1.1.1 Group 1A

Group 1A shellfish tissue results were obtained from small (<7.5 cm) sedentary bivalves (e.g., clams, mussels, oysters). Exhibits 11-4 and 11-5 present the range, mean, and standard deviation of the COPCs most frequently detected of the Group 1A shellfish.

SVOCs PAHs

The SVOC analysis of Group 1A shellfish tissue samples identified the detection of 18 SVOC analytes. Benzaldehyde, benzo(a)pyrene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene were the most frequently detected analytes at mean concentrations of 421

µg/Kg, 20.9 µg/Kg, 1.62 µg/Kg, and 0.60 µg/Kg, respectively. Benzaldehyde was the only SVOC detected in all three Group 1A shellfish in the reference area at a mean concentration of 1,500 µg/Kg. No PAHs were detected in the reference area samples.

Pesticides

The pesticide analysis of Group 1A shellfish tissue samples indicated the presence of 11 analytes with low detection of frequency. 4,4-DDE was detected most frequently at a mean concentration of 2.12 µg/Kg.

Exhibit 11-4 Summary Statistics for Detects (µg/Kg) in Group 1A Shellfish

Parameter	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	21/21	31	2000	421.71	617.05
Benzo(a)pyrene	18/23	0.84	240	20.97	65.59
Benzo(g,h,I)perylene	15/18	1	3.3	1.62	0.62
Indeno(1,2,3-cd)pyrene	15/18	0.34	1.1	0.60	0.23
4,4-DDE	8/39	1	3.7	2.12	0.99
Aroclor 1254	8/39	17	74	12.50	16.62
2,3,7,8-TCDD TEQ (pg/g)	7/7	1.4	20.25	6.72	8.66

PCBs (Aroclors) and PCB Congeners

The Group 1A shellfish tissue sample collected and analyzed for PCB aroclors and PCB congeners indicated detections of PCB Aroclor 1254 as the most frequently detected aroclor. The mean concentration of Aroclor 1254 was 12.5 µg/Kg. Nine PCB congeners were detected, and the most frequently detected and highest concentrations were for PCB-118, PCB-105, and PCB-162 at 5,729 pg/g, 1,426 pg/g, and 1,016 pg/g, respectively. Only one reference area was analyzed for PCB arolors and PCB congeners. The same PCB congeners detected in the reference area were significantly power concentration at PCB-118 (73 pg/g), PCB-105 (21.8 pg/g), and PCB-162 (18.7 pg/g.

Dioxin/Furans

Group 1A shellfish tissue samples collected and analyzed for dioxin/furans identified several compounds above detection limits. The most frequently detected dioxin/furans compound was 2,3,7,8-TCDF. TEQs are used to report the *toxicity-weighted masses* of mixtures of dioxins and furans. The TEQ method of dioxin reporting is more meaningful than simply reporting the *total number of grams* of a mixture of variously toxic compounds because the TEQ method offers toxicity information about the mixture. In addition, it is a convenient method to compare dioxin/furans as a group throughout the estuary in various media. Within the TEQ method, each dioxin compound is assigned a Toxic Equivalency Factor, or TEF. This factor denotes a given dioxin compound's toxicity relative to 2,3,7,8-TCDD, which is assigned the maximum toxicity designation of one. Other dioxin compounds are given equal or lower numbers, with each number roughly proportional to its toxicity relative to that of 2,3,7,8-TCDD.

Metals
Group 1A shellfish tissue samples collected and analyzed for metal constituents identified several COPCs above detection limits. The most frequently detected metals were arsenic, copper, lead, mercury, methyl mercury, nickel, selenium, and zinc.

Exhibit 11-5 Summary Statistics for Metals (mg/Kg) Detected in Group 1A Shellfish

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	22/39	0.18	0.63	0.32	0.10
Copper	25/39	0.86	163	13.64	36.61
Lead	17/39	0.14	1.2	0.22	0.212
Mercury	36/39	.002	0.314	0.0395	0.062
Methyl Mercury	36/39	.0038	0.0797	0.0140	0.0217
Nickel	38/39	0.25	2.6	**0.902**	0.497
Selenium	18/39	0.22	1.6	**0.427**	0.352
Zinc	24/39	4.4	2080	121.304	427.504

Bold = similar to reference area

Arsenic was detected at a higher mean concentration in the reference area of 0.763 mg/Kg. Copper was detected significantly lower in the reference area at a range of 0.82 mg/Kg to 1.7 mg/Kg. Lead was not detected in the reference area samples. Mercury was detected in all three reference area samples at a mean concentration of 0.009 mg/Kg, significantly lower than the estuary. Zinc was detected at a much higher mean concentration in the estuary than the reference area (5.6 mg/Kg). Nickel and selenium were detected at a similar mean concentration as reference area for Group 1A shellfish at 0.463 mg/Kg and 0.46 mg/Kg.

11.2.1.1.2 Group 1B
Group 1B shellfish tissue analytical results were obtained from small (<7.5 cm) sedentary crustaceans (e.g., fiddler crabs, hermit crabs, and juvenile blue crabs). Exhibits 11-6 and 11-7 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 1B shellfish. Group 1B shellfish tissues were not collected from the reference area.

SVOCs and PAHs
SVOCs were not detected in Group 1B shellfish tissues. A total of 18 PAHs were detected in Group 1B samples. PAHs detected most frequently included benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, phenanthrene, and pyrene.

Pesticides
The pesticide analysis of Group 1B shellfish tissue samples identified 12 analytes. These analytes were observed at relatively comparable concentrations to the other sampled areas at low concentrations and frequency.

Exhibit 11-6 Summary Statistics for Detects (µg/Kg) in Group 1B Shellfish

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzo(a)pyrene	7/9	0.68	6.5	3.60	2.06
benzo(b)fluoranthene	7/9	0.62	8.8	4.29	2.73
Benzo(g,h,I)perylene	8/9	0.74	7.8	4.16	2.22
benzo(a)anthracene	8/9	0.68	6.5	3.60	2.06
Phenanthrene	7/9	0.79	7.8	3.94	2.31
Pyrene	7/9	1.2	15	6.92	4.6
Dieldrin	2/9	1.2	4.3	NA	NA
4,4-DDE	2/9	1.2	3.8	NA	NA
Gamma-BHC	2/9	0.96	1.2	NA	NA
Aroclor 1254	5/9	19	34	27	6.5
Aroclor 1260	5/9	18	35	26.7	6.89
2,3,7,8-TCDF pg/g	3/3	4.75	6.21	5.58	0.87
2,3,7,8-TCDD TEQ pg/g	3/3	5.48	85.83	32.84	61.96

PCBs (Aroclors) and PCB Congeners

PCBs Aroclor 1254 and Aroclor 1260 were the most frequently detected, as in other areas. The mean concentrations of Aroclor 1254 and 1260 were 27 and 26.7 µg/Kg, respectively. PCB congeners were analyzed in three samples from this group, with the highest concentrations associated with PCB-129, PCB-110/77, and PCB-118 (mean concentrations equal 11,463, 6,506, and 5,176 µg/Kg, respectively).

Dioxin/Furans

Three samples were analyzed from Group 1B shellfish for dioxin/furan analysis. Thirty-four analytes were detected, with 2,3,7,8-TCDF being the most frequently detected at a mean concentration of 5.58 pg/g.

Metals

The metals analysis of Group 1B shellfish tissue samples identified several COPCs above detection limits. The most frequently detected were arsenic, chromium, copper, lead, mercury, methyl mercury, and nickel.

Exhibit 11-7 Summary Statistics for Metals (mg/Kg) Detected in Group 1B Shellfish

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	7/9	0.8	1	0.832	0.10
Chromium	3/9	0.73	1.3	0.64	0.57
Copper	9/9	0.64	33	24.22	11.15
Lead	7/9	0.47	2.2	1.04	0.71
Mercury	9/9	0.011	0.12	0.063	0.036
Methyl Mercury	7/7	0.024	0.095	0.051	0.025
Nickel	7/9	0.3	0.62	0.48	0.13

11.2.1.1.3 Group 2A

Group 2A shellfish tissue results were obtained from small (<12.5 cm) migratory crustaceans of low trophic level (e.g., shrimp). Exhibits 11-8 and 11-9 present the range,

mean, and standard deviation of the COPCs most frequently detected in the Group 2A shellfish.

SVOCs and PAHs
The SVOC analysis of Group 2A shellfish tissue samples identified the detection of nine SVOC analytes at low frequency of detection and concentration. Benzaldehyde was the most frequently detected analyte in shellfish tissue. The mean benzaldehyde concentration identified during analysis was 110.28 µg/Kg. Benzaldehyde was observed in the reference samples at a high frequency of detection (8/9), with a mean concentration of 105.63 µg/Kg. This concentration is similar to the concentration observed in the estuary Group 2A shellfish.

Pesticides
No pesticide analytes were detected in the Group 2A shellfish collected or observed in the reference area samples analyzed. A total of 10 samples were collected and analyzed.

Exhibit 11-8 Summary Statistics for Detects (µg/Kg) in Group 2A Shellfish

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	42/51	16	310	110.28	75.23
2,3,7,8-TCDF (pg/g)	7/7	13.2	33.1	22.941	7.12
2,3,7,8- TCDD TEQ (pg/g)	7/7	1.14	2.79	2.35	0.67

PCBs (aroclors) and PCB Congeners
Group 2A shellfish tissue samples collected and analyzed for PCB aroclors and PCB congeners indicated very low frequency of detects of PCB aroclors and detections of 18 PCB congeners. Eleven PCB congeners were detected in the shellfish tissue samples. The PCB congeners that were observed with the highest frequency of detection and the greatest mean concentrations were PCB-118 (4,467 pg/g), PCB-105 (1,010 pg/g), and PCB-61/70 (1,402 pg/g). In the reference area Group 2A shellfish, PCB-118 and PCB 66 were frequently detected (3/3), with a mean concentration of 927.66 and 277.33 µg/Kg, respectively. The comparison to reference indicates the PCB-118 concentrations in the estuary are much higher than that detected in the reference area for Group 2A shellfish.

Dioxin/Furans
Group 2A shellfish tissue samples collected and analyzed for dioxin/furans identified 10 compounds above detection limits. The most frequently detected dioxin/furan was 2,3,7,8-TCDF, with a mean concentration of 22.941 pg/g. The highest concentration observed in reference area Group 2A shellfish was 0.265 pg/g.

Metals
Group 2A shellfish tissue samples collected and analyzed for metals identified several COPCs above detection limits. The most frequently detected metals in the shellfish tissue samples were arsenic, chromium, copper, lead, mercury, methyl mercury, selenium, and zinc. In comparison to reference area, a majority of the metals were similar to that observed in reference area Group 2A shellfish. Nickel was not detected in reference area samples, methyl mercury was not analyzed for in reference samples, and

selenium was observed at a higher mean concentration in the estuary than observed in the reference area (0.034 mg/Kg).

Exhibit 11-9 Summary Statistics for Metals (mg/Kg) Detected in Group 2A Shellfish

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	50/52	0.13	0.6	**0.38**	0.098
Chromium	42/52	0.16	1.4	**0.415**	0.323
Copper	52/52	8.8	24.2	**14.84**	2.82
Lead	33/52	0.08	1.7	**0.207**	0.327
Mercury	52/52	0.006	0.049	**0.028**	0.009
Methyl Mercury	31/31	0.0094	0.0375	0.0251	0.007
Nickel	16/52	0.18	0.47	0.173	0.11
Selenium	52/52	0.17	0.96	0.535	0.174
Zinc	52/52	6.7	37.3	**11.75**	4.99

Bold = similar to reference area

11.2.1.1.4 Group 2B

Group 2B shellfish results were obtained from large (>12.5 cm) mobile crustaceans (e.g., blue crabs). Exhibits 11-10 and 11-11 present the range, mean, and standard deviation of the COPCs most frequently detected in the Group 2B shellfish.

SVOCs and PAHs

The SVOC analysis of Group 2B shellfish tissue samples identified the detection of three SVOC analytes. The most frequently detected SVOC compound was benzaldehyde. The mean concentration of benzaldehyde was 150 µg/Kg. Benzaldehyde was observed in the reference area samples at a high frequency (6/7), with a mean concentration of 233.09 µg/Kg. HCB was detected at a low frequency of detection in estuary samples and was not observed in reference area samples.

Pesticides

Pesticide analysis of the Group 2B shellfish tissue samples identified infrequent detections of several pesticides. 4,4-DDT and beta-BHC were the most frequently detected pesticides. There were no detections of pesticides in the Group 2B shellfish in the reference area samples.

Exhibit 11-10 Summary Statistics for Detects (µg/Kg) in Group 2B Shellfish

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	21/21	38	660	150	150
HCB	3/15	20	28	24.79	4.87
4,4-DDT	5/22	14	43	9.75	13.24
Beta-BHC	8/22	10	56	14.37	14.98
Aroclor1254	19/22	13	330	77.85	84.71
2,3,7,8-TCDF (pg/g)	5/5	4.96	69.7	41.39	29.86
2,3,7,8-TCDD TEQ (pg/g)	5/5	2.72	24.7	14.7	10.1

PCBs (Aroclors) and PCB Congeners

Group 2B shellfish tissue samples collected and analyzed for PCB aroclors and PCB congeners indicated detections of PCB Aroclor 1254 and detections of PCB congeners.

Aroclor 1254 was observed at a high frequency of detection in estuary Group 2B shellfish but was not detected in reference area samples. PCB congeners observed with the highest concentration in the reference area were PCB-118, PCB-66, PCB-162, and PCB-105 at 4,660, 1,560, 607, and 851 pg/g, respectively.

Dioxin/Furans
Group 2B shellfish tissue samples collected and analyzed for dioxin/furans identified eight compounds above detection limits. The most frequently detected was 2,3,7,8-TCDF, which was detected in two reference area samples analyzed, with the highest concentration of 2.18 pg/g. The concentrations observed in the reference area samples are significantly lower than those observed in estuary Group 2B shellfish.

Metals
Group 2B tissue samples collected and analyzed for metals identified 19 analytes above detection limits. COPC metals detected included arsenic, copper, lead, mercury, nickel, selenium, and zinc in the Group 2B shellfish tissue samples. All concentrations of metals were similar to those of the reference area.

Exhibit 11-11 Summary Statistics for Metals (mg/Kg) Detected in Group 2B Shellfish

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	21/22	0.25	0.97	**0.53**	0.20
Copper	22/22	6.2	15.6	**8.97**	2.33
Lead	13/22	0.03	0.67	**0.09**	0.166
Mercury	22/22	0.04	0.302	**0.12**	0.077
Nickel	21/22	0.06	0.21	**0.099**	0.034
Selenium	22/22	0.36	1.6	**0.87**	0.295
Zinc	22/22	20.3	36.2	**28.51**	4.78

Bold = similar to reference area

11.2.1.2 Fish

11.2.1.2.1 Group 1

Group 1 fish tissue results were obtained from small (<15 cm) sedentary species of low trophic level (e.g., sheepshead minnows, blennies, gobies, and mollies). Exhibits 11-12 and 11-13 present the range, mean, and standard deviation of the COPCs most frequently detected in Group 1 fish.

SVOCs and PAHs
The SVOC analysis of Group 1 fish tissue samples indicated the detection of three analytes. Benzaldehyde and phenol were the most frequently detected. Benzaldehyde (12/12) and phenol (5/12) were the most frequently detected SVOCs in the reference area. Benzaldehyde had a mean concentration in the reference area of 2,899 µg/Kg and the mean phenol concentration was 335.5 µg/Kg.

Pesticides
The pesticide analysis of Group 1 fish tissue samples identified two analytes, 4,4'-DDT and endrin. These analytes were only detected in one sample and at a very low concentration. These compounds were observed at similar frequency and concentration in the reference area samples.

Exhibit 11-12 Summary Statistics for Detects (µg/Kg) in Group 1 Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	81/124	28	6400	640.19	1118.64
Phenol	77/124	110	8200	869.01	1155.86
Aroclor1254	80/128	12	820	84.82	144.72
Aroclor1260	32/127	12	90	13.92	13.67
2,3,7,8-TCDD TEQ (pg/g)	27/27	0.25	12.2	3.52	3.82

PCBs (Aroclors) and PCB Congeners

Group 1 fish tissue samples collected and analyzed for PCB aroclors and PCB congeners indicated detections of PCB Aroclor1254, Aroclor1260, and 18 PCB congeners. Aroclor1254 was the most frequently detected compound and was observed in the reference area at a similar frequency and at a mean concentration of 76.10 µg/Kg. PCB congeners observed with the highest frequencies and highest mean concentrations included PCB-118 (14,589 pg/g), PCB-105 (3,733 pg/g), PCB-162 (3,468 pg/g), and PCB-66 (3,275 pg/g). Similar frequency of detections and concentrations were observed in reference area samples for Group 1 fish tissue. The mean concentrations for reference samples are PCB-118 (19,900 pg/g), PCB-162 (3,600 pg/g), and PCB-66 (3,093 pg/g).

Dioxin/Furans

Group 1 fish tissue samples collected and analyzed for dioxin/furans identified six compounds above detection limits. The most frequently detected dioxin/furan was 2,3,7,8-TCDF.

Metals

Group 1 fish tissue samples collected and analyzed for metal constituents identified several COPCs above detection limits. The most frequently detected metals were arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc. Of these metals copper, mercury, selenium, and zinc were observed at lower concentrations in the reference area Group 1 fish tissue samples.

Exhibit 11-13 Summary Statistics for Metals (mg/Kg) Detected in Group 1 Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	115/129	0.08	0.91	**0.24**	0.106
Chromium	129/129	0.19	2.1	**0.36**	0.199
Copper	129/129	0.91	17.4	3.158	2.46
Lead	98/129	0.02	4.3	**0.278**	0.488
Mercury	129/129	0.011	0.65	0.146	0.146
Nickel	102/129	0.03	0.63	**0.079**	0.078
Selenium	127/129	0.13	2.9	0.49	0.29
Zinc	129/129	19	188	35.184	17.58

Bold = similar to reference area

11.2.1.2.2 Group 2A

Group 2A fish tissue results were obtained from small (<15 cm) migratory species of low trophic level (e.g., mullet, anchovies, sunfish, and menhaden). Exhibits 11-14 and 11-15 present the range, mean, and standard deviation of the COPCs frequently detected in the Group 2A fish.

SVOCs and PAHs

The SVOC analysis of Group 2A fish tissue samples identified the detection of two SVOC analytes. Benzaldehyde was also the most frequently detected analyte in the whole body analysis. Benzaldehyde was observed in the reference area at a similar frequency, with a mean concentration of 3,680 µg/Kg.

Pesticides

Pesticides were detected in one Group 2A fish at very low frequencies of detection and concentration. Pesticides were not detected in reference area samples.

Exhibit 11-14 Summary Statistics for Detects (µg/Kg) in Group 2A Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	30/31	330	39000	9757.38	12635.67
Aroclor 1254	21/34	14	100	40.12	25.70
Aroclor 1260	7/34	12	90	10.87	21.21
2,3,7,8-TCDD TEQ (pg/g)	6/6	0.39	24.8	12.06	9.57

PCBs (Aroclors) and PCB Congeners

Group 2A fish tissue samples collected and analyzed for PCB aroclors and PCB congeners indicated detections of PCB Aroclors1254 and Aroclor1260 and detections of 18 PCB congeners. Aroclor 1254 was the most frequently detected and was not observed in reference area Group 2A fish tissue. PCB congeners observed most frequently included PCB-118 (20,275 pg/g), PCB-66 (8,158 pg/g), PCB-162 (4,605 pg/g), and PCB-61/70 (6,717 pg/g). The same PCB congeners were observed at a similar frequency in the reference area, with the highest concentrations of 3,790, 951, 733, and 1,050 pg/g.

Dioxin/Furans

Group 2A fish tissue samples collected and analyzed for dioxin/furans identified 18 compounds above detection limits. The most frequently detected dioxin/furan was 2,3,7,8-TCDF. 2,3,7,8-TCDF was detected with similar frequency in the reference area, with a maximum concentration of 1.33 pg/g.

Metals

Group 2A fish tissue samples collected and analyzed for metals identified several COPCs above detection limits. The most frequently detected metals in the fish tissue samples were arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc. These same metals were observed at similar frequency and range of concentrations as the reference area, with the exception of arsenic, chromium, and mercury. Arsenic was observed with greater range of detects in the reference area, chromium lower frequency and concentration in the reference area, and mercury similar frequency of detects but a lower mean concentration in the reference area.

Exhibit 11-15 Summary Statistics for Metals (mg/Kg) Detected in Group 2A Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	33/34	0.15	0.81	0.423	0.123
Chromium	34/34	0.25	1.4	0.75	0.36
Copper	34/34	0.47	4.4	**1.85**	0.97

Lead	34/34	0.06	1.7	**0.707**	0.44
Mercury	34/34	0.013	0.275	0.86	0.069
Nickel	33/34	0.06	0.53	**0.256**	0.122
Selenium	34/34	0.23	1.1	**0.677**	0.146
Zinc	34/34	9.1	37.8	**23.57**	6.03

Bold = similar to reference area

11.2.1.2.3 Group 2B

Group 2B fish tissue results were obtained from small migratory or mobile species (< 15 cm) of high trophic level (e.g., pinfish, spotted trout, southern puffer, juvenile scianid, and Atlantic croaker). Exhibits 11-16 and 11-17 present the range, mean, and standard deviation of the COPCs most frequently detected in Group 2B fish. There were no Group 2B fish samples collected from the reference area for comparison.

SVOCs and PAHs

The SVOC analysis of Group 2B fish tissue samples identified the detection of six SVOC analytes. Benzaldehyde was also the most frequently detected analyte in the whole body analysis. HCB and HCBD were detected at a very low frequency, with maximum detected concentrations of 94 and 26 μg/Kg, respectively. Two PAHs were detected, with naphthalene most frequently detected.

Pesticides

Pesticides were detected at a low frequency of detection and concentration in the Group 2B fish tissue. The most frequently detected pesticide was beta-BHC, followed by 4,4-DDE.

Exhibit 11-16 Summary Statistics for Detects (μg/Kg) in Group 2B Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	21/21	150	2200	462.38	508.14
Naphthalene	9/21	61	97	68.32	10.74
4,4-DDE	4/24	10	13	NA	NA
Beta-BHC	16/24	10	130	28.22	32.69
Aroclor 1254	23/24	22	180	65.43	48.97
Aroclor 1260	22/24	12	110	40.60	27.49
2,3,7,8-TCDF (pg/g)	4/4	0.881	4	2.68	1.577
2,3,7,8-TCDD TEQ (pg/g)	4/4	2.08	10.48	6.35	4.60

NA – Not available

PCBs (Aroclors) and PCB Congeners

Group 2B fish tissue samples collected and analyzed for PCB aroclors and PCB congeners indicated frequent detections of PCB Aroclors 1254 and 1260 and detections of 21 PCB congeners. Aroclor 1254 was the most frequently detected. The most frequently detected PCB congeners with the highest mean concentrations included PCB-118 (20,852 pg/g), PCB-66 (6,512 pg/g), and PCB-105 (4957 pg/g), respectively.

Dioxin/Furans
Group 2B fish tissue samples collected and analyzed for dioxin/furans identified 21 compounds above detection limits. The most frequently detected dioxin/furan was 2,3,7,8-TCDF.

Metals
Group 2B fish tissue samples were collected and analyzed for metals. The results of these analyses identified several COPCs above detection limits. The most frequently detected metals in the fish tissue samples were arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc.

Exhibit 11-17 Summary Statistics for Metals (mg/Kg) Detected in Group 2B Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	22/22	0.2	0.63	0.40	0.10
Chromium	22/22	0.22	0.62	0.33	0.11
Copper	22/22	0.55	9	1.22	2.34
Lead	21/22	0.1	0.78	0.18	0.17
Mercury	22/22	0.018	0.163	0.062	0.037
Nickel	18/22	0.05	0.31	0.11	0.06
Selenium	22/22	0.38	0.77	0.59	0.13
Zinc	22/22	10.4	31.1	17.11	4.96

11.2.1.2.4 Group 3A
Group 3A fish tissue results were obtained from medium (15 to <30 cm) migratory or mobile species of low trophic level (mullet, anchovies, menhaden, and herring). Exhibits 11-18 and 11-19 present the ranges, means, and standard deviations of the COPCs detected most frequently in Group 3A fish.

SVOCs and PAHs
The SVOC analysis of Group 3A fish tissue samples identified the detection of three SVOC analytes and two PAH analytes. Benzaldehyde and hexachloro-1,3-butadiene were the most frequently detected SVOC analytes. 2-Methylnaphthalene and naphthalene were the only detected PAHs. All four compounds were detected in tissue samples from the reference areas at similar frequencies of detection and at mean concentrations of 1,122.55, 613.08, 52.44, and 84.55 µg/Kg, respectively.

Pesticides
The pesticide analyses of Group 3A fish tissue samples indicated the presence of eight analytes. 4,4'-DDD and beta-BHC were the most frequently detected analytes and were observed in reference area samples at mean concentrations of 17 and 28.25 µg/Kg, respectively.

Exhibit 11-18 Summary Statistics for Detects (μg/Kg) in Group 3A Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	34/36	66	3000	1077.96	830.02
HCBD	18/36	22	1800	263.41	370.74
2-Methylnaphthalene	7/35	26	100	45.025	22.60
Naphthalene	6/35	28	280	NA	NA
4,4-DDE	12/36	11	57	11.09	14.39
Beta-BHC	26/36	13	440	84.17	104.62
Aroclor 1254	34/36	25	2800	330.92	558.88
Aroclor 1260	34/36	19	1100	159.85	215.66
2,3,7,8-TCDF (pg/g)	6/6	1.78	118	47.96	50.18
2,3,7,8-TCDD TEQ (pg/g)	6/6	0.39	24.80	12.06	9.57

PCBs (Aroclors) and PCB Congeners

Group 3A fish tissue samples were analyzed for PCB aroclors and PCB congeners, and results indicated detections of PCB Aroclor 1254 and 1260 and 17 PCB congeners. Aroclor1254 and 1260 were detected at similar frequencies with Aroclor 1254 having the higher mean concentration. Aroclor 1254 and 1260 were both observed in the reference area at similar frequencies of detection but at lower mean concentrations (64.95 μg/Kg and 40.35 μg/Kg, respectively). PCB-118 (58,788 pg/g), PCB-162 (11,483 pg/g), PCB-61/70 (19,430 pg/g), PCB-105 (15,075 pg/g), and PCB-66 (21,375 pg/g) were the most frequently detected PCB congeners. PCB congeners PCB-118, PCB-162, and PCB-61/70 were the most frequently detected in the reference area at 15,800, 3,580, and 9,180 pg/g, respectively.

Dioxin/Furans

Group 3A fish tissue samples were analyzed for dioxin/furans, and results revealed 20 compounds above detection limits. 2,3,7,8-TCDF was the most frequently detected dioxin/furan. 2,3,7,8-TCDF was detected in both samples collected in the reference area, with the highest concentration of 7.5 pg/g. This concentration is significantly lower than that of the estuary Group 3A fish tissues for 2,3,7,8-TCDF.

Metals

Group 3A fish tissue samples collected and analyzed for metals identified several COPCs above detection limits. All detected metal analytes were frequently observed and included arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc.

Exhibit 11-19 Summary Statistics for Metals (mg/Kg) Detected in Group 3A Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	36/36	0.28	1.1	0.599	0.20
Chromium	35/36	0.21	1.9	**0.553**	0.335
Copper	36/36	0.86	14.2	**5.99**	3.47
Lead	36/36	0.04	1.5	**0.62**	0.404
Mercury	37/37	0.01	0.244	0.0765	0.060
Nickel	23/36	0.07	1.1	**0.23**	0.214
Selenium	36/36	0.3	0.89	**0.577**	0.14
Zinc	36/36	9.1	29.7	**18.83**	4.36

Bold = similar to reference area

The same metals were observed in the reference area and at similar concentrations, with the exception of arsenic, which was higher in the reference area, and mercury, which was lower in the reference area than in the Group 3A fish tissue.

11.2.1.2.5 Group 3B

Group 3B fish tissue results were obtained from medium (15 to <30 cm) migratory or mobile fish species assigned to a high trophic level (e.g., puffer, croaker, sea trout, black drum, and redfish). Exhibits 11-20 and 11-21 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 3B fish.

SVOCs and PAHs

The SVOC analysis of Group 3B fish tissue samples identified six SVOC analytes and one PAH. Benzaldehyde and hexachloro-1, 3-butadiene were the most frequently detected analytes. Benzaldehyde and HCBD were both detected at similar frequencies in the reference area at mean concentrations of 646.28 µg/Kg and 100.71 µg/Kg, respectively.

Pesticides

The pesticide analysis of Group 3B fish tissue samples indicated the presence of eight analytes, all at low concentrations and frequency of detection. Beta-BHC was the most frequently detected pesticide with a mean concentration of 16.04 µg/Kg. Beta-BHC was detected at a much lower frequency (3/23) in the reference area, with the highest concentration equal to 230 µg/Kg.

Exhibit 11-20 Summary Statistics for Detects (µg/Kg) in Group 3B Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	53/58	170	1900	598.02	418.64
HCBD	29/71	27	880	81.83	127.80
Beta-BHC	27/60	10	150	16.04	23.80
Aroclor 1254	41/71	19	730	92.88	126.33
Aroclor 1260	46/71	12	360	56.148	72.73
2,3,7,8-TCDF (pg/g)	13/15	0.186	4.28	1.37	1.34
2,3,7,8-TCDD TEQ (pg/g)	15/15	0.22	4.08	1.74	1.28

PCBs (Aroclors) and PCB Congeners
Group 3B fish tissue samples were collected and analyzed for PCB aroclors and PCB congeners. These analyses indicated two detections of PCB Aroclors 1254 and 1260 and detections of 17 PCB congeners. Both aroclors were detected at similar frequency and concentration. The reference area results indicate Aroclor 1254 and 1260 at lower concentrations of 27 and 16 µg/Kg, respectively. PCB-105 (4,699 pg/g), PCB-118 (19,264 pg/g), and PCB-66 (4,578 pg/g) were the most frequently detected PCB congeners. Similar frequencies of detection were observed in the reference area for the same PCB congeners but at lower concentrations.

Dioxin/Furans
Group 3B fish tissue samples were analyzed for dioxin/furans. These analyses identified seven compounds above detection limits. 2,3,7,8-TCDF was the most frequently detected dioxin/furan. The frequency of detection was similar for 2,3,7,8-TCDF for the reference area sample, with the highest concentration of 0.668 pg/g.

Metals
Group 3B fish tissue samples collected and analyzed for metals identified several COPCs above detection limits. Arsenic, copper, chromium, lead, mercury, nickel, selenium, and zinc were the most frequently detected metals. All the metals were observed at similar concentrations as the reference area, with the exception of mercury. Mercury was detected at a mean concentration of 0.019 mg/Kg for Group 3B fish tissue in the reference area.

Exhibit 11-21 Summary Statistics for Metals (mg/Kg) Detected in Group 3B Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	47/69	0.13	1.5	**0.346**	0.216
Chromium	61/69	0.08	0.78	**0.266**	0.128
Copper	62/69	0.28	7	**0.812**	0.97
Lead	34/69	0.05	0.52	**0.088**	0.09
Mercury	63/70	0.015	0.251	0.080	0.051
Nickel	47/69	0.03	0.98	**0.0855**	0.142
Selenium	62//69	0.25	2	**0.672**	0.354
Zinc	68/69	8.5	29.9	**14.52**	4.55

Bold = similar to reference area

11.2.1.2.6 Group 4A
Group 4A fish tissue sample results were obtained from large migratory or mobile species (30 to 90 cm) assigned to low trophic level (e.g., mullet and shad). Exhibit 11-22 and 11-23 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 4A fish.

SVOCs and PAHs
The SVOC analysis of Group 4A fish tissue samples identified four SVOC analytes. Benzaldehyde was the most frequently detected followed by HCBD.

Diethyl phthalate was the only SVOC detected in Group 4A reference area samples at a concentration of 58 µg/Kg.

Pesticides
The pesticide analyses of Group 4A fish tissue samples indicated the presence of several pesticides at a frequency of detection of less than 50 percent. 4,4'-DDE and beta-BHC were the most frequently detected pesticide analytes. 4,4-DDE was detected in the reference area at a maximum concentration of 18 µg/Kg.

Exhibit 11-22 Summary Statistics for Detects (µg/Kg) in Group 4A Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	33/41	140	4200	600.35	773.98
HCBD	27/44	26	1100	113.42	196.10
HCB	3/22	140	280	NA	NA
4,4-DDE	19/44	9.2	39	12.99	8.99
Beta-BHC	28/43	6	300	55.18	75.52
Aroclor 1254	37/43	12	2300	506.11	592.22
Aroclor 1260	36/43	14	2000	293.75	447.21
2,3,7,8-TCDF (pg/g)	9/9	2.28	158	43.80	57.72
2,3,7,8-TCDD TEQ (pg/g)	9/9	1.02	57.35	15.74	20.81

NA = Not available

PCBs (Aroclors) and PCB Congeners
Group 4A fish tissue samples were collected and analyzed for PCB aroclors and PCB congeners. These results revealed detection of PCB aroclors 1254 and 1260 as well as detections of 18 PCB congeners. Both aroclors were detected at similar frequencies of detection and concentrations. In the reference area samples, Aroclor1254 was detected in only one sample at a concentration of 1,800 µg/Kg. The PCB congeners that were most frequently detected include PCB-118 (41,214 pg/g), PCB-66 (14,493 pg/g), PCB-105 (9,573 pg/g), and PCB-162 (8,317 pg/g). In the reference area samples, PCB-118, PCB-66, and PCB-61/70 had the highest concentrations of 3,660, 1,330, and 1,048 pg/g, respectively. Aroclors were not observed at the same frequency as the estuary samples although concentrations were similar. PCB congeners were detected at a higher concentration in the estuary than the reference area.

Dioxin/Furans
Group 4A fish tissue samples were also analyzed for dioxin/furans, and these analyses identified several COPCs above detection limits. 2,3,7,8-TCDF was the most frequently detected in the estuary (158 pg/g) and the reference area (7.14 pg/g). Although frequency of detection was similar for the estuary and the reference area, the concentrations observed were significantly higher in the estuary.

Metals
The results of analyses of Group 4A fish tissue samples for metals identified several COPCs above detection limits. Arsenic, chromium, copper, iron, lead, mercury, nickel, and selenium were the most frequently detected metals. With the exception of lead, mercury, and zinc, all other metals were observed at similar mean concentrations. Lead was observed at a lower mean concentration in the reference area at 0.193 mg/Kg, and

mercury was observed at 0.02 mg/Kg. Zinc was not observed in the estuary samples but was detected in the reference area samples at a mean concentration of 18.4 mg/Kg.

Exhibit 11-23 Summary Statistics for Metals (mg/Kg) Detected in Group 4A Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	40/41	0.18	1	**0.39**	0.187
Chromium	40/41	0.1	1.5	**0.541**	0.389
Copper	41/41	0.35	25.5	**4.78**	6.17
Lead	40/41	0.05	37.2	1.36	8.11
Mercury	41/44	0.012	0.229	0.053	0.044
Nickel	38/41	0.04	0.76	**0.25**	0.182
Selenium	40/41	0.24	1.6	**0.563**	0.251

Bold = similar to reference area

11.2.1.2.7 Group 4B

Group 4B fish tissue samples results were obtained from large migratory or mobile species (30 to 90 cm) assigned to high trophic level (e.g., redfish, black drum, and flounder). Exhibits 11-24 and 11-25 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 4B fish.

SVOCs and PAHs

The SVOC analysis of Group 4B fish tissue samples identified several SVOCs. Benzaldehyde, bis (2-ethylhexyl) phthalate (BEHP), and diethyl phthalate were the most frequently identified SVOCs. In the reference area samples, HCBD was the most frequently observed SVOC, with a mean concentration of 83.51 µg/Kg. A single detection of diethyl phthalate equaled 32 µg/Kg. Benzaldehyde was not detected in the Group 4B tissue samples from the reference area.

Pesticides

The pesticide analysis of Group 4B fish tissue samples resulted in the detection of multiple pesticides but at low frequencies of detection and low concentrations. Beta-BHC was the most frequently (<20 percent) detected. No pesticides were detected in the reference area Group 4B tissue samples.

Exhibit 11-24 Summary Statistics for Detects (µg/Kg) in Group 4B Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	12/50	26	1000	52.45	179.126
BEHP	15/51	230	7000	357.59	1265.68
Diethyl Phthalate	24/52	25	93	40.53	13
HCBD	9/52	30	220	NA	NA
Aroclor 1254	39/52	12	1100	78.27	187.08
Aroclor 1260	32/52	11	710	43.12	122.54
2,3,7,8-TCDF (pg/g)	9/9	0.194	30.8	4.24	13.62
2,3,7,8-TCDD TEQ (pg/g)	9/9	0.27	10.5	1.88	4.25

NA – Not available

PCBs (Aroclors) and PCB Congeners
Group 4B fish tissue samples revealed detections of Aroclor 1254 and 1260 as well as detections of 19 PCB congeners. Aroclors 1254 and 1260 were both detected in the reference area samples at similar frequencies of detection and lower mean concentrations of (25.25 µg/Kg and 8.33 µg/Kg, respectively). PCB-118 (17,862 pg/g), PCB-105 (4,391 pg/g), PCB-162 (3,796 pg/g), and PCB-66 (4,834 pg/g) were associated with the highest mean concentrations of detected PCB congeners in Group 4B tissue samples. PCB-118, PCB-105, and PCB-162 were associated with the highest concentrations observed in the Group 4B reference area samples (1,227 pg/g, 299 pg/g, and 427 pg/g, respectively).

Dioxin/Furans
Group 4B fish tissue samples revealed 10 compounds measured above detection limits. 2,3,7,8-TCDF was the most frequently detected dioxin/furan analyte in the Group 4B tissue analysis. 2,3,7,8-TCDF was detected at 0.627 pg/g in the reference area sample.

Metals
Analysis of samples of Group 4B fish identified several COPCs above detection limits. Of these, arsenic, chromium, copper, lead, nickel, mercury, selenium, and zinc were most often observed above detection limits. Arsenic and copper were observed at higher mean concentrations in the reference area at 0.66 mg/Kg and 10.025 mg/Kg, respectively while lead was not detected in reference area Group 4B tissue samples. All other metals were observed at similar concentrations in reference and test areas.

Exhibit 11-25 Summary Statistics for Metals (mg/Kg) Detected in Group 4B Fish Tissue

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	52/52	0.11	1.5	0.328	0.23
Chromium	50/52	0.08	0.63	**0.215**	0.132
Copper	52/52	0.24	4.1	0.765	0.62
Lead	20/52	0.004	0.49	0.043	0.083
Mercury	51/52	0.016	0.71	**0.153**	0.122
Nickel	47/52	0.03	0.58	**0.089**	0.089
Selenium	52/52	0.15	1.6	**0.615**	0.255
Zinc	52/52	3.1	22.3	**8.95**	4.23

Bold = similar to reference area

11.2.2 Upper Calcasieu Extent of Tissue Contamination
This section discusses Group 1 shellfish and sedentary fish of the Upper Calcasieu. These results are compared to reference samples. Group 2, 3, and 4 samples were discussed in the previous sections and are not further discussed because of their migratory behavior in the estuary.

11.2.2.1 Shellfish
11.2.2.1.1 Group 1A
Group 1A shellfish tissue analytical results were obtained from small (<7.5 cm) bivalves (e.g., clams, mussels, oysters). Figure 11-1 illustrates the areas within Upper Calcasieu from which the Group 1A samples were collected, as well as their corresponding

sediment sample locations. Exhibits 11-26 and 11-27 present the ranges, means, and standard deviations of the COPCs detected most frequently in Group 1A shellfish in Upper Calcasieu. There were no Group 1A shellfish collected from the reference area.

SVOCs and PAHs

The SVOC analysis of Group 1A shellfish revealed detections of five analytes at low concentrations. Eighteen PAHs were detected in the Group 1A tissue samples. The most frequently detected compounds (10/12) include benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene, with mean concentrations of 1.066 µg/Kg, 1.48 µg/Kg, 1.10 µg/Kg, 1.25 µg/Kg, and 0.47 µg/Kg, respectively. Benzaldehyde was the only SVOC detected in reference area samples at a mean concentration of 1,500 µg/Kg. No PAHs were detected in the reference area Group 1A shellfish.

Pesticides

The pesticide analysis of Group 1A shellfish indicated the presence of 14 analytes associated with low frequencies of detection and low concentrations. 4,4'-DDE was the most frequently detected pesticide (3 of 22 samples or 14 percent), at concentrations ranging from1.8 to 2.7 µg/Kg. No pesticides were detected in the reference area Group 1A shellfish.

Exhibit 11-26 Summary Statistics for Detects (µg/Kg) in Group 1A Shellfish – Upper Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	11/11	31	320	131.45	86.691
Benzo(a)pyrene	10/12	0.84	1.4	1.066	1.68
Benzo(b)fluoranthene	10/12	0.99	2.2	1.48	0.44
Benzo(g,h,I)perylene	10/12	1	1.6	1.25	0.16
Benzo(k)fluoranthene	10/12	0.5	2.1	1.10	0.567
Indeno(1,2,3-cd)pyrene	10/12	0.34	0.68	0.47	0.114
2,3,7,8-TCDD TEQ (pg/g)	1/1	2.26	2.26	-	-

PCBs (Aroclors) and PCB Congeners

Group 1A shellfish were analyzed for PCB aroclors. Aroclors 1254 and 1260 were detected in less than 10 percent of the samples analyzed and at low concentrations. PCB congeners were not analyzed. Concentrations in the reference area were at a lower concentration than Upper Calcasieu.

Dioxin/Furans

One Group 1A shellfish tissue sample was collected and analyzed for dioxin/furans, and this resulted in the identification of 13 compounds above detection limits.

Metals

Group 1A shellfish tissue samples collected and analyzed for metal constituents identified several COPCs above detection limits. Arsenic, chromium, copper, mercury, methyl mercury, nickel, selenium, and zinc were the most frequently detected analytes.

Exhibit 11-27 Summary Statistics for Metals (mg/Kg) Detected in Group 1A Shellfish – Upper Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	12/22	0.18	0.63	0.296	0.111
Chromium	10/22	0.091	0.22	0.117	0.036
Copper	12/22	0.86	2.9	**1.357**	0.731
Lead	7/22	0.14	0.25	0.16	0.045
Mercury	20/22	0.002	0.0056	0.0194	0.0148
Methyl Mercury	11/11	0.0038	0.0068	0.0049	0.00105
Nickel	22/22	0.37	1.2	**0.82**	0.25
Selenium	8/22	0.22	0.66	**0.264**	0.142
Zinc	12/22	4.9	11.5	**6.08**	1.74

Bold – Similar to reference area

Arsenic (0.763 mg/Kg) was detected at a higher mean concentration in the reference area than Upper Calcasieu. Chromium and Lead were not detected in the reference area Group 1A shellfish and mercury was detected significantly higher in Upper Calcasieu than in reference area (0.009 mg/Kg) samples. All other metals were detected at similar mean concentrations.

11.2.2.1.2 Group 1B

Group 1B shellfish tissue analytical results were obtained from small (<7.5 cm) sedentary crustaceans (e.g., fiddler crabs, hermit crabs, and juvenile blue crabs). Exhibits 11-28 and 11-29 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 1B shellfish. Group 1B shellfish tissues were not collected from the reference area.

SVOCs and PAHs

SVOCs were not detected in Group 1B shellfish tissues. 18 PAHs were detected in Group 1B samples. PAHs detected most frequently included benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(a)anthracene, and pyrene.

Pesticides

The pesticide analysis of Group 1B shellfish tissue samples identified three analytes. These analytes were alpha-chlordane, dieldrin, and heptachlor epoxide at maximum concentrations of 0.43 µg/Kg, 1.2 µg/Kg, and 0.83 µg/Kg, respectively. These analytes were observed at relatively comparable concentrations to the other sampled areas.

Exhibit 11-28 Summary Statistics for Detects (μg/Kg) in Group 1B Shellfish – Upper Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzo(a)anthracene	3/3	2.3	6.5	4.96	2.99
Benzo(a)pyrene	3/3	2.9	6.1	4.47	1.79
Benxo(b)fluoranthene	3/3	3.2	8.8	6.27	3.23
Benzo(g,h,I)perylene	3/3	2.8	5.2	4	1.34
Phenanthrene	3/3	1.9	7.8	4.5	3.47
Pyrene	3/3	3.6	15	9.87	6.60

PCBs (Aroclors) and PCB Congeners

PCBs Aroclor 1254 and Aroclor 1260 were detected in one of three samples analyzed at maximum concentrations of 20 and 26 μg/Kg, respectively. PCB congeners were not analyzed in three samples from the Group 1B shellfish from Upper Calcasieu.

Metals

The metals analysis of Group 1B shellfish tissue samples identified several COPCs above detection limits. The most frequently detected were arsenic, copper, lead, mercury, methyl mercury, and nickel.

Exhibit 11-29 Summary Statistics for Metals (mg/Kg) Detected in Group 1B Shellfish – Upper Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	3/3	0.8	0.93	0.86	0.077
Copper	3/3	22	29	25	4.22
Lead	1/3	0.72	0.77	NA	NA
Mercury	3/3	0.025	0.052	0.041	0.015
Methyl Mercury	3/3	0.024	0.041	0.035	0.012
Nickel	3/3	0.3	0.38	0.34	0.044

11.2.2.2 Fish

11.2.2.2.1 Group 1

Group 1 fish tissue analytical results were derived from small (<15 cm) sedentary species (e.g., killifish, sheepshead minnows, blennies, and gobies). Exhibits 11-30 and 11-31 present the ranges, means, and standard deviations of the COPCs detected in greater than 5 percent of the Group 1 fish.

SVOCs and PAHs

The SVOC analysis of Group 1 whole body fish tissue identified four analytes, and 2-Methylphenol, 4-methylphenol, benzaldehyde, and phenol were most frequently detected. 2-Methylphenol and 4-methylphenol were not identified in the reference area Group 1 samples. While benzaldehyde was detected at the same frequency in the Upper Calcasieu Group 1 tissues as the reference area Group 1 tissues, the mean concentration identified in Upper area was lower than that observed in the reference area (2,899

µg/Kg). Phenol was detected more frequently in the Upper Calcasieu Group 1 tissue analysis than in the reference area Group 1 tissues. Additionally, the mean phenol concentration observed in the Upper Calcasieu was greater than that observed in the reference area (335 µg/Kg).

Pesticides
Pesticides were not detected in the Group 1 fish tissue analysis.

Exhibit 11-30 Summary Statistics for Detects (µg/Kg) in Group 1 Fish Tissue – Upper Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
2-Methylphenol	7/29	64	340	54.50	85.71
4-Methylphenol	10/29	56	300	72.23	73.78
Benzaldehyde	18/29	140	6400	831.87	1702.55
Phenol	16/29	240	4900	675.21	1072.08
Arolcor 1254	6/33	12	35	NA	NA
2,3,7,8-TCDF (pg/g)	6/6	0.139	0.57	0.307	0.185
2,3,7,8-TCDD TEQ (pg/g)	6/6	0.25	1.21	0.52	0.42

NA – Not available

PCBs (Aroclors) and PCB Congeners
PCB Aroclor 1254 was the only detected aroclor in the Group 1 tissue analysis for Upper Calcasieu. PCB congeners were analyzed in only six samples within this group. The PCB congeners with the highest mean concentration included PCB-118, PCB-162, and PCB-105 at 4,481 pg/g, 1,103 pg/g, and 1,023 pg/g, respectively. PCB Aroclor 1254 was detected in both the Upper Calcasieu sample and the reference area Group 1 sample. However, the concentrations of Aroclor 1254 were higher in the reference area, with a mean concentration of 76 µg/Kg. When concentrations of PCB congeners identified in the reference area Group 1 tissue samples are compared to the concentrations of PCB congeners identified in the Upper Calcasieu Group 1 tissues, those present in Upper Calcasieu were lower.

Dioxin/Furans
The results of Group 1 fish tissue samples collected and analyzed for dioxin/furans identified 18 compounds above detection limits but at low frequencies and low concentrations. The most frequently detected compound was 2,3,7,8-TCDF, with a mean concentration of 0.307 pg/g. Group 1 tissue analysis of the Upper Calcasieu samples identified more dioxin/furan analytes than in the reference area Group 1 tissue samples. 2,3,7,8-TCDF in the Group 1 tissue reference area samples was detected in all three samples, with a mean concentration of 0.424 pg/g. The concentrations of 2,3,7,8-TCDF appear to be similar or slightly lower in the Upper Calcasieu tissue sample group compared to those from the reference area.

Metals
Group 1 fish tissue samples were collected and analyzed for several metal parameters. The results identified several COPCs above detection limits. Arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc were the most frequently detected

and, when compared to Group 1 tissue reference area samples. Arsenic, mercury, and selenium in the Upper Calcasieu data was lower than that observed in the reference area, and zinc in the Upper Calcasieu data was greater than that observed in the reference area.

Exhibit 11-31 Summary Statistics for Metals (mg/Kg) Detected in Group 1 Fish Tissue – Upper Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	30/34	0.27	0.46	0.3166	0.043
Chromium	34/34	0.26	0.51	**0.341**	0.0614
Copper	34/34	1.1	3.3	**1.756**	0.637
Lead	26/34	0.03	0.88	**0.141**	0.22
Mercury	34/34	0.011	0.127	0.048	0.029
Nickel	22/34	0.03	0.11	**0.0467**	0.022
Selenium	34/34	0.23	0.89	0.403	0.127
Zinc	34/34	31.2	45.7	35.80	3.30

Bold = similar to reference area

11.2.3 Lower Calcasieu Extent of Tissue Contamination

This section only discusses the Group 1 shellfish and fish that are sedentary within the Lower Calcasieu and compares these data to data from reference samples. The migratory groups 2, 3, and 4 were discussed in previous sections and are not discussed further.

11.2.3.1 Shellfish

11.2.3.1.1 Group 1A

Group 1A shellfish tissue results were obtained from small (<7.5 cm) bivalves (e.g., clams, mussels, and oysters). Exhibits 11-32 and 11-33 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 1A shellfish in Lower Calcasieu.

SVOCs and PAHs

The SVOC analysis of Group 1A shellfish tissue samples identified three SVOC analytes and three PAH analytes. Benzaldehyde was the most commonly detected SVOC, at a mean concentration of 430 µg/Kg. Benzo(a)pyrene was the most frequently detected PAH, at a mean concentration of 110.37 µg/Kg. Benzaldehyde was the only SVOC detected in reference area samples at a mean concentration of 1,500 µg/Kg. No PAHs were detected in the reference area Group 1A shellfish.

Pesticides

Pesticides were not detected in the Group 1A tissue analysis.

Exhibit 11-32 Summary Statistics for Detects (µg/Kg) in Group 1A Shellfish – Lower Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	7/7	37	2000	430	921.64
Benzo(a)pyrene	3/5	27	240	110.37	132.27
2,3,7,8-TCDD TEQ (pg/g)	3/3	1.41	2.38	1.85	0.56

PCBs (Aroclors) and PCB Congeners

Group 1A shellfish tissue samples were collected and analyzed for PCBs and PCB congeners. No PCB aroclors were detected. PCB congeners were detected in two samples analyzed within the Group 1A shellfish. The highest detected congeners were PCB-118, PCB-66, and PCB-61/70 at 3,650 pg/g, 1,230 pg/g and 1,200 pg/g, respectively. Concentrations of similar congeners in the reference area were significantly at a much lower detection of frequency and concentration PCB-118 at 73 pg/g.

Dioxin/Furans

The results of Group 1A tissue samples collected and analyzed for dioxin/furans identified 21 compounds above detection limits.

Metals

Arsenic, copper, lead, mercury, methyl mercury, nickel, selenium, and zinc were the most frequently detected metals.

Exhibit 11-33 Summary Statistics for Metals (mg/Kg) Detected in Group 1A Shellfish – Lower Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	7/8	0.21	0.45	0.32	0.083
Copper	8/8	1.7	163	60.475	60.79
Lead	7/8	0.17	1.2	0.42	0.40
Mercury	8/8	0.01	0.039	0.019	0.012
Methyl Mercury	7/7	0.0061	0.0104	0.008	0.001
Nickel	7/8	0.25	0.72	**0.41**	0.18
Selenium	7/8	0.25	1.6	**0.89**	0.49
Zinc	8/8	5.3	2000	569.81	790.36

Bold = Similar to reference area

With the exception of nickel and selenium all metals detected in Group 1A shellfish in Lower Calcasieu were higher than that detected in reference area. Copper (0.82 mg/Kg to 1.7 mg/Kg) and zinc (5.6 mg/Kg) were significantly higher than the reference area.

11.2.3.1.2 Group 1B

Group 1B shellfish tissue results were obtained from the analysis of small (<7.5 cm) sedentary crustaceans (e.g., fiddler crabs, juvenile blue crabs, and hermit crabs). Exhibit 11-34 presents the range, mean, and standard deviation of the COPCs detected most frequently in the Group 1B shellfish. There was only one Group 1B shellfish sample collected in Lower Calcasieu.

SVOCs and PAHs
SVOCs and PAHs were not detected in the Group 1B tissue analysis.

Pesticides
The pesticide analysis of Group 1B tissue samples identified three analytes in the single shellfish tissue sample at very low concentrations.

Exhibit 11-34 Summary Statistics for Metals (mg/Kg) Detected in Group 1B Shellfish – Lower Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Copper	1/1	20.3	20.3	NA	NA
Lead	1/1	0.98	0.98	NA	NA
Mercury	1/1	0.011	0.011	NA	NA
Selenium	1/1	0.83	0.83	NA	NA
Zinc	1/1	19.1	19.1	NA	NA

NA – Not available

PCBs (Aroclors) and PCB Congeners
PCBs were not detected in the Group 1B tissue analysis.

Dioxin/Furans
Dioxin/furan analysis was not performed on Group 1B tissue.

Metals
One group 1B tissue sample was collected and analyzed for metal constituents. Metals detected included copper, lead, mercury, selenium, and zinc.

11.2.3.2 Fish

11.2.3.2.1 Group 1

Group 1 fish results were obtained from the analysis of small (<15 cm) sedentary species (e.g., killifish, sheepshead minnows, and blennies) assigned to a low trophic level. Exhibits 11-35 and 11-36 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 1 fish.

SVOCs and PAHs
The SVOC analysis of Group 1 samples resulted in the detection of nine analytes. Benzaldehyde and phenol were most frequently detected. Benzaldehyde was detected at a slightly lower frequency in the whole body tissues from the Lower Calcasieu Group 1 than in the reference area. The mean concentration of benzaldehyde and phenol in the reference area was 2,899 µg/Kg and 335 µg/Kg, respectively. HCBD was detected in one sample, at a concentration of 29 µg/Kg, and was not detected in any reference area samples.

Pesticides
The pesticide analysis of Group 1 samples identified endosulfan sulfate in one sample at a concentration of 30 µg/Kg. No pesticides were observed in the Group 1 reference area samples.

Exhibit 11-35 Summary Statistics for Detects (µg/Kg) in Group 1 Fish Tissue – Lower Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	14/17	170	5000	1036.20	1704.24
Phenol	6/17	330	800	328.31	182.49
Aroclor-1254	6/17	25	140	23.41	39.67
2,3,7,8-TCDF (pg/g)	3/3	1.54	1.91	1.71	0.21
2,3,7,8-TCDD TEQ (pg/g)	3/3	1.58	2.01	1.74	0.30

PCBs (Aroclors) and PCB Congeners
The results of Group 1 tissue analyses for PCBs and PCB congeners indicated the presence of one PCB aroclor and 18 PCB congeners. PCB Aroclor 1254 was the only detected analyte identified during the analysis, with a mean concentration of 23.41 µg/Kg. PCB analyses for the Lower Calcasieu Group 1 whole body tissues revealed approximately the same detection frequency when compared to the reference area Group 1 data. PCB Aroclor 1254 was detected at a lower mean concentration in Lower Calcasieu compared to the reference area mean of 76 µg/Kg.

PCB-118, PCB-105, and PCB-162 were detected, with mean concentrations of 22,100 pg/g; 7,780 pg/g; and 6,110 pg/g, respectively, and were the most frequently detected. All PCB congeners detected in the Lower Calcasieu data were also identified in the reference area and at concentrations comparable to those of the reference area.

Dioxin/Furans
Three group 1-tissue samples were collected and analyzed for dioxin/furans. 2,3,7,8-TCDF was detected at a mean concentration of 1.71 pg/g. Dioxin/furan analysis of the Lower Calcasieu Group 1 tissues identified analytes at approximately the same frequency as in the reference area. Mean concentrations of analytes detected in both the Lower Calcasieu data and the reference group data were similar. The greatest difference between the Lower Calcasieu data and the reference group data was the finding of 21 analytes identified in the Lower Calcasieu and only six analytes detected in the reference group.

Metals
Arsenic was detected less frequently in the Lower Calcasieu Group 1 samples than in the reference area samples. In addition to the detection frequency being higher in the reference area, the mean of the Lower Calcasieu data (0.24 mg/Kg) is similar to the range of the reference area data (0.38 mg/Kg).

Chromium was detected at the same frequency in the Lower Calcasieu Group 1 tissue analysis as in the reference area. The mean concentration of the Lower Calcasieu results (0.32 mg/Kg) was similar to that of the reference area (0.33 mg/Kg).

Copper was detected at the same frequency in the Lower Calcasieu Group 1 samples as in the reference area samples. The means of the two groups are similar, with the mean of the Lower Calcasieu data (2.5 mg/Kg) slightly exceeding that of the mean for the reference area data (2.02 mg/Kg).

Exhibit 11-36 Summary Statistics for Metals Detects (mg/Kg) in Group 1 Fish Tissue – Lower Calcasieu

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	8/17	0.24	0.43	**0,24**	0.092
Chromium	17/17	0.26	0.51	**0.32**	0.07
Copper	17/17	1.0	7.3	**2.5**	2.1
Lead	8/17	0.04	0.59	0.142	0.20
Mercury	17/17	0.029	0.134	0.067	0.31
Nickel	8/17	0.04	0.24	0.054	0.064
Selenium	15/17	0.13	0.63	**0.33**	0.17
Zinc	17/17	27.8	37.2	**31.94**	2.66

Bold = similar mean value to reference area.

Nickel was detected at a higher frequency in the reference area than in Lower Calcasieu for group 1 tissue analyses. The mean nickel concentration of Lower Calcasieu data (0.054 mg/Kg) is lower than that of the reference area (0.085 mg/Kg).

Mercury was detected at the same frequency in the Lower Calcasieu Group 1 tissue as in the reference area. The mean concentration of the Lower Calcasieu data (0.067 mg/Kg) exceeds that of the reference area (0.022 mg/Kg).

Selenium was also detected at a similar frequency in both the Lower Calcasieu and the reference area. The mean concentration of selenium was higher in the Lower Calcasieu (0.33 mg/Kg) than the mean for the reference area (0.017 mg/Kg).

Zinc was detected at a similar frequency in the Lower Calcasieu and reference area samples collected for Group 1 tissue analyses. The mean concentration for the Lower Calcasieu (31.94 mg/Kg) slightly exceeds the mean for the reference area (29.26 mg/Kg).

11.2.4 Bayou d'Inde Extent of Tissue Contamination

This section only discusses the Group 1 shellfish and fish that are sedentary residents of Bayou d'Inde, and compares the results of analyses of these data to results from reference area samples. The more mobile or migratory groups 2, 3, and 4 were discussed in previous sections.

11.2.4.1 Shellfish

11.2.4.1.1 Group 1A

Group 1A shellfish tissue sample results were obtained from small (<7.5 cm) sedentary bivalves (e.g., clams, mussels, and oysters). Exhibits 11-37 and 11-38 present the ranges,

means, and standard deviations of the COPCs detected most frequently in Group 1A shellfish.

SVOCs and PAHs

The SVOC analysis of Group 1A shellfish tissue samples identified one SVOC analyte and 18 PAH analytes. Benzaldehyde was detected at an equal frequency in the shellfish analysis of both Bayou d'Inde Group 1A and the reference area. Most frequently detected PAHs in the Bayou d'Inde Group 1A shellfish include benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, benzo(a,h)anthracene, and ideno(1,2,3-cd)pyrene. No PAHs were detected in the Group 1A shellfish tissue samples.

Pesticides

The pesticide analysis of Group 1A shellfish tissue samples indicated the presence of 12 analytes. Beta-BHC was the most frequently detected, at a mean concentration of 30.34 µg/Kg. Other detected pesticides include 4,4-DDD, 4,4-DDT, and endrin, at mean concentrations of 13.76 µg/Kg, 32.13 µg/Kg, and 10.76 µg/Kg, respectively. These same pesticides were not identified in the single sample taken from the reference area.

Exhibit 11-37 Summary Statistics for Detects (µg/Kg) in Group 1A Shellfish – Bayou d'Inde

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldeyde	3/3	1300	1600	1466.66	175.41
Benzo(a)pyrene	5/6	1.6	2.2	1.92	0.23
Benzo(b)fluoranthene	5/6	1.7	2.6	2.04	0.37
Benzo(g,h,I)perylene	5/6	2	3.3	2.39	0.58
Benzo(k)fluoranthene	5/6	0.84	1.6	1.19	0.36
Benzo(a,h)anthracene	5/6	0.52	0.93	0.71	0.15
Ideno(1,2,3-cd)pyrene	5/6	0.71	1.1	0.88	0.15
1-Methylnaptthalene	5/5	0.33	0.59	0.448	0.132
Beta-BHC	6/8	25	56	30.34	13.83
Aroclor1254	6/9	17	74	29.80	24.61
2,3,7,8-TCDF (pg/g)	3/3	3.28	46.2	30.83	31.26
2,3,7,8-TCDD TEQ (pg/g)	3/3	1.40	20.25	13.07	12.81

PCBs (Aroclors) and PCB Congeners

Group 1A shellfish tissue samples collected and analyzed for PCBs and PCB congeners indicated detections of PCB Aroclor 1254 and Aroclor 1260, with Aroclor 1254 being the most frequently detected. The mean concentrations of Aroclor 1254 and Aroclor 1260 were 29.80 µg/Kg and 13.85 µg/Kg, respectively. Aroclor 1254 was not identified in reference area sample. Only one sample from this group was analyzed for PCB congeners, and those with the highest frequency of detection were PCB-118, PCB-61/70, and PCB-129 (detected at 12,600 pg/g, 5,980 pg/g, and 6,020 pg/g, respectively). PCB congener analytes detected in both Bayou d'Inde Group 1A shellfish tissue and reference area Group 1A shellfish tissue was observed at the same frequency but at a much lower concentrations in the reference area samples.

Dioxin/Furans
Group 1A shellfish tissue samples collected and analyzed for dioxin/furans identified 24 compounds above detection limits. Detected dioxins/furans in the Bayou d'Inde Group 1A shellfish were identified at approximately the same frequency as the reference area samples. However, the mean concentration of the Bayou d'Inde results exceeded the mean of the reference samples. The most frequently detected compound in the Bayou was 2,3,7,8-TCDF, with a mean of 30.83 pg/g.

Metals
Group 1A shellfish tissue samples were collected and analyzed for metal constituents of which 18 metals were identified above detection limits.

Arsenic was detected at a lower frequency in the Bayou d'Inde shellfish Group 1A data than in the reference area data. The mean concentration of the reference area data was greater than the mean of the Bayou d'Inde data. The mean arsenic concentration in the reference area data was 0.76 mg/Kg.

Copper was detected at an equal frequency in the Bayou d'Inde Group 1A tissue analysis as in the reference area. The mean concentration for the Bayou d'Inde results exceeded the range of the reference area (0.82 mg/Kg to 1.7 mg/Kg).

Mercury was also detected at an equal frequency in both the Bayou d'Inde and reference area. The mean of the Bayou d'Inde results exceeded that of the reference area (0.009 mg/Kg).

Exhibit 11-38 Summary Statistics for Metals (mg/Kg) Detected in Group 1A Shellfish – Bayou d'Inde

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	3/9	0.27	0.61	0.425	0.135
Chromium	5/9	0.1	0.23	0.154	0.054
Copper	5/9	1.8	6.1	**2.72**	1.89
Lead	3/9	0.16	0.33	0.185	0.089
Mercury	9/9	0.031	0.314	0.108	0.1
Methyl Mercury	3/3	0.05	0.08	0.062	0.019
Nickel	9/9	0.49	2.6	1.49	0.61
Selenium	3/9	0.36	0.82	**0.46**	0.25
Zinc	4/9	4.4	8.5	**5.6**	1.41

Bold = similar to reference area

Nickel was detected as frequently in the Bayou d'Inde Group 1A tissue analysis as in the reference area. The mean concentration of the Bayou d'Inde results was greater than that of the reference area (0.463 mg/Kg).

Selenium was detected at a lower frequency in the Bayou d'Inde Group 1A tissue analysis than in the reference area. The mean concentrations for the Bayou d'Inde results were similar to that of the reference area (0.46 mg/Kg).

Zinc was detected with equal frequency in both the Bayou and the reference area. The mean concentration of Bayou d'Inde data was marginally greater than that of the reference area data set (5.6 mg/Kg).

Chromium and lead were not detected in the Group 1A shellfish from the reference area.

11.2.4.1.2 Group 1B

Group 1B shellfish tissue analytical results were obtained from small (<7.5 cm) sedentary crustaceans (e.g., fiddler crabs, hermit crabs, and juvenile blue crabs). Exhibits 11-39 and 11-40 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 1B shellfish. Group 1B shellfish tissues were not collected from the reference area.

SVOCs and PAHs

SVOCs were not detected in Group 1B shellfish tissues. 18 PAHs were detected in Group 1B samples. PAHs detected most frequently included benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, benzo(a,h)anthracene, ideno(1,2,3-cd)pyrene, and pyrene.

Pesticides

The pesticide analysis of Group 1B shellfish tissue samples identified 12 analytes. These analytes were observed at relatively comparable concentrations to the other sampled areas. As in the other areas, the pesticide beta-BHC was the most frequently detected compound, with a mean concentration of 30.34 µg/Kg.

Exhibit 11-39 Summary Statistics for Detects (µg/Kg) in Group 1B Shellfish – Bayou d'Inde

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzo(a)pyrene	4/5	0.81	6.5	3.42	2.4
Benzo(b)fluoranthene	4/5	0.62	5.3	2.92	1.97
Benzo(g,h,I)perylene	4/5	0.74	7.8	4.2	3.01
Benzo(k)fluoranthene	4/5	0.39	2.7	1.42	0.97
Benzo(a)anthracene	4/5	0.68	4.4	2.64	1.61
Ideno(1,2,3-cd)pyrene	4/5	0.36	3.1	1.57	1.16
Pyrene	4/5	1.2	7.5	4.9	2.97
1-Methylnapthalene	4/4	0.28	0.64	0.475	0.165
Beta-BHC	6/8	25	56	30.34	13.83
Aroclor 1254	4/5	19	34	28.86	7.72
2,3,7,8-TCDF (pg/g)	3/3	4.75	6.21	5.58	0.87
2,3,7,8-TCDD TEQ (pg/g)	3/3	5.48	85.83	32.84	61.96

PCBs (Aroclors) and PCB Congeners

PCBs Aroclor 1254 and Aroclor 1260 were the most frequently detected, as in other areas. The mean concentrations of Aroclors 1254 and 1260 were 28.8 µg/Kg and 27.04 µg/Kg, respectively. PCB congeners were analyzed in three samples from this group, with the highest concentrations associated with PCB-129, PCB-110/77, and PCB-118 (mean concentrations equal 11,463 pg/g, 6,506 pg/g, and 5,176 pg/g, respectively).

Dioxin/Furans
Three samples were analyzed from Group 1B shellfish for dioxin/furan analysis. Thirty-four analytes were detected, with 2,3,7,8-TCDF being the most frequently detected at a mean concentration of 5.58 pg/g.

Metals
The metals analysis of Group 1B shellfish tissue samples identified several COPCs above detection limits. The most frequently detected were arsenic, copper, lead, mercury, and nickel.

Exhibit 11-40 Summary Statistics for Metals (mg/Kg) Detected in Group 1B Shellfish – Bayou d'Inde

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	4/5	0.8	1	0.832	0.130
Copper	5/5	0.64	33	24.53	17.82
Lead	4/5	0.47	2.2	1.32	0.95
Mercury	5/5	0.062	0.12	0.09	0.026
Nickel	4/5	0.54	0.62	0.58	0.033

11.2.4.2 Fish

11.2.4.2.1 Group 1

Group 1 fish tissue results were obtained from small (<15 cm) sedentary species assigned to a low trophic level (e.g., killifish, blennies, gobies, and mollies). Exhibits 11-41 and 11-42 present the ranges, means, and standard deviations of the COPCs detected most frequently in the Group 1 fish.

SVOCs and PAHs
The SVOC analysis of Group 1 fish samples indicated the presence of nine analytes. Additionally, one PAH was identified in these samples. 4-Methylphenol, Benzaldehyde, and phenol were the most frequently detected SVOCs.

Benzaldehyde was detected less frequently in the whole body tissue analysis of Bayou d'Inde Group 1 than in the reference area samples. The reference area Group mean concentration of 2,899 μg/Kg exceeds the mean observed in Bayou d'Inde (484 μg/Kg). The mean concentration of benzaldehyde was an order of magnitude lower than the mean of the reference area for Group 1 whole body fish samples.

Pesticides
The pesticide analysis of Group 1 fish samples identified three analytes at low frequency of detection and low concentrations. Beta-BHC was the most frequently detected (6/78) pesticide identified.

Exhibit 11-41 Summary Statistics for Detects (μg/Kg) in Group 1 Fish Tissue – Bayou d'Inde

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Benzaldehyde	49/78	28	3300	484.30	599.82
Phenol	56/78	110	8200	1071.23	1287.66

Aroclor 1254	68/78	12	820	129.24	170.38
2,3,7,8-TCDF (pg/g)	18/18	0.735	17.6	6.96	6.203
2,3,7,8-TCDD TEQ (pg/g)	18/18	0.40	12.22	4.82	4.07

PCBs (Aroclors) and PCB Congeners

Group 1 fish tissue samples collected and analyzed for PCBs and PCB congeners indicated the presence of Aroclor 1254 and 19 PCB congeners. PCB aroclor analysis for the Bayou d'Inde Group 1 samples was associated with much greater detection frequencies compared to the reference area. PCB Aroclor 1254 was detected at a mean concentration of 76.1 µg/Kg in the reference area. All PCB congeners detected in the Bayou d'Inde Group 1 tissue data were identified at similar frequencies when compared to the reference area results. The congeners detected with the highest concentration in Bayou d'Inde Group 1 tissue samples included PCB-118, PCB-162, PCB-105, and PCB-66, with mean concentrations of 16,773 pg/g, 3,875 pg/g, 3,975 pg/g, and 4,062 pg/g, respectively.

Dioxin/Furans

Group 1 fish tissue samples collected and analyzed for dioxin/furans identified 25 compounds above detection limits. 2,3,7,8-TCDF was the most total frequently detected, with a mean concentration of 0.424 pg/g in the reference area.

Dioxin/furan analysis of the Bayou d'Inde Group 1 tissue samples identified analytes at similar detection frequencies as in the reference Group Area Group 1 tissue samples. Mean concentrations of analytes detected in both the Bayou d'Inde data and the reference group data were higher in the Bayou d'Inde samples. Also, 25 analytes were identified in the Bayou d'Inde and only 6 analytes were detected in the reference area samples.

Metals

Group 1 fish tissue samples were collected and analyzed for metal constituents of which 11 metals were identified above detection limits.

Arsenic was detected more frequently in Bayou d'Inde than in the reference area. Even though the detection frequency was greater in the bayou, the mean concentration of the Bayou d'Inde data was lower than that of the reference area data (0.43 mg/Kg).

Chromium was detected more frequently in the Bayou d'Inde Group 1 tissue analysis than in the reference area Group 1 tissue analysis. The mean concentration of the Bayou d'Inde results was slightly higher than that of the reference area data (0.31 mg/Kg).

Exhibit 11-42 Summary Statistics for Metals (mg/Kg) Detected in Group 1 Fish Tissue – Bayou d'Inde

Parameter	Frequency of Detects	Minimum Detected Value	Maximum Detected Value	Mean	Standard Deviation
Arsenic	77/78	0.08	0.91	**0.21**	0.11
Chromium	78/78	0.19	2.1	**0.38**	0.25
Copper	78/78	0.91	17.4	3.92	2.7

Lead	64/78	0.02	4.3	0.37	0.60
Mercury	78/78	0.013	0.65	**0.205**	0.16
Nickel	75/78	0.03	0.63	**0.097**	0.093
Selenium	78/78	0.23	2.9	0.56	0.35
Zinc	78/78	19	188	35.62	22.82

Bold = Similar to reference area.

Copper was detected more frequently in the Bayou d'Inde Group 1 tissue analysis than in the reference area Group 1 tissue analysis. The mean concentration of the Bayou d'Inde data was greater than that of the reference area data (1.6 mg/Kg).

Lead was also detected more frequently in the Bayou d'Inde samples than in the reference area samples. The mean lead concentration of the Bayou d'Inde data exceeded that of the reference area (0.10 mg/Kg).

Mercury was detected more frequently in the Bayou d'Inde Group 1 tissue analysis than in the reference area Group 1 tissues. The mean concentration in the Bayou d'Inde was greater than that of the reference area (0.024 mg/Kg).

Nickel was detected more frequently in the Bayou d'Inde than in the reference area. Mean concentrations of this analyte were virtually identical in both data sets.

Selenium was detected more frequency in Bayou d'Inde than in the reference area. The mean concentration of selenium was higher in the Bayou d'Inde.

Zinc was detected more frequently in Bayou d'Inde than in the reference area. The mean concentration of the Bayou d'Inde samples was greater than that of the reference area (28.8 mg/Kg).

11.2.5 Summary

Tissue samples from a variety of aquatic biota were collected and analyzed for chemicals of concern. These data were used to assess risks to fish, wildlife resources, and human health. These data also support the feasibility study and potential future remedial actions.

This summary section discusses the tissue data by AOC and by biota group. The four AOCs in the estuary are Upper Calcasieu, Bayou d'Inde, Lower Calcasieu, and the reference area. Biota groups, presented previously as Exhibit 11-2, are repeated below as Exhibit 11-43.

Exhibit 11-43 Description of Biota Groups for the Calcasieu Estuary

Type	Group	Description of Group	Size Class (cm)
Fish	1	Small sedentary species – low trophic level (<2.5)	<15 cm
Invertebrates	1A	Small sedentary bivalves	<7.5 cm
Invertebrates	1B	Small sedentary crustaceans	<7.5 cm
Invertebrates	2A	Small migratory crustaceans	<12.5 cm
Invertebrates	2B	Large migratory crustaceans	>12.5 cm

Fish	2A	Small migratory species - low trophic level (<2.5)	<15 cm
Fish	2B	Small migratory species - high trophic level (>2.5)	<15 cm
Fish	3A	Medium migratory species - low trophic level (<2.5)	15 to <30 cm
Fish	3B	Medium migratory species – high trophic level (>2.5)	15 to <30 cm
Fish	4A	Large migratory species - low trophic level (>2.5)	30 to 90 cm
Fish	4B	Large migratory species - high trophic level (>2.5)	30 to 90 cm

Finally, the relationships between COPCs concentrations in sediment and in biological tissues are evaluated for small sedentary bivalves (Group 1A biota) that are directly and continuously exposed to potentially contaminated sediments. These relationships are expressed as biota-sediment accumulation factors (BSAFs) that are based on the following equation:

BSAF = COPCs concentration in biota / COPCs concentration in sediment

COPCs concentrations are expressed as mg/Kg dry weight sediment and mg/Kg wet weight biota. The BSAFs presented in this section are not normalized for biota lipids or for sediment organic carbon content. BSAFs are not calculated for other biota groups because of more limited and less direct contact with potentially contaminated sediments. For example, most fish are expected to accumulate contaminants primarily as a result of water rather than sediment exposure. Also, other types of invertebrates (e.g., crustaceans) that are more mobile will be exposed to sediments over a wider spatial area. The mobility of these types of organisms precludes an accurate determination of relationships between COPCs concentrations in sediment and those in biota.

Sitewide Results for Biota Groups 2A – 4B

Sitewide results include the results of sampling of migratory/mobile biota throughout the site. This approach is appropriate because little difference was observed in the tissue COPCs concentrations of Groups 2, 3, and 4 migratory/mobile fish and crustaceans. The sitewide results are presented by COPCs class and by mobile/migratory biota group.

As presented in Exhibit 11-44, and in general, there is little difference in the types of analytes detected and the most frequently detected analytes from one biota group to another. These summary data encompass all the data from the three areas and, where available, the reference area.

In a few cases, comparisons of the summary data from the three areas to reference area data indicate significant differences. Two types of differences are observed. Contamination of reference areas by unknown sources can be concluded where reference area COPCs concentrations exceed the area concentrations in similar biota. This situation is observed occasionally with benzaldehyde and infrequently with 2,3,7,8-TCDF. On the other hand, significant AOC contamination can be interpreted where the concentrations of COPCs in AOC biota substantially exceed those of

reference area biota. This case is observed more commonly with the PCB congener PCB-118 and 2,3,7,8-TCDF. These COPCs were commonly detected in AOC biota at concentrations that substantially exceeded those of the reference area. These are important findings because of the high toxicity and bioaccumulation potential of these COPCs. In general, the frequencies of detection and the concentrations of other COPCs such as metals were similar in both the reference area biota and the AOC biota, based on the overall data for all three AOCs.

Exhibit 11-44 Sitewide Summary of Biota Tissue Data, Groups 2A to 4B

Biota Group	Metals	SVOCs/ PAHs	PCBs	Pesticides	Dioxins/Furans
2A Invertebrates	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	9 DET, MFD = benzaldehyde at conc ~RA	MFD = PCB-118 at conc >> RA	ND, and ND in RA	10 DET, MFD = 2,3,7,8-TCDF at conc >>RA
2B Invertebrates	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	3 DET, MFD = benzaldehyde at conc< RA	MFD = Aroclor 1254 (ND in RA) and PCB-118	MFD = DDT and beta-BHC	8 DET, MFD = 2,3,7,8-TCDF at conc > RA
2A Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	2 DET, MFD = benzaldehyde at FD and conc~RA	MFD = Aroclor 1254 (ND in RA) and PCB-118 at conc ~ to RA	Few DET at low FD and conc	18 DET, MFD = 2,3,7,8-TCDF at conc ~ RA
2B Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	6 DET, MFD = benzaldehyde	MFD = Aroclor 1254 and PCB-118	MFD = beta-BHC and DDE	21 DET, MFD = 2,3,7,8-TCDF
3A Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	5 DET, MFD = benzaldehyde at conc ~RA	MFD = Aroclors 1254 and 1260 at conc ~ RA and PCB-118 at conc > RA	8 DET, MFD = DDD and beta-BHC	20 DET, MFD = 2,3,7,8-TCDF at conc < RA
3B Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	7 DET, MFD = benzaldehyde at conc ~RA	MFD = Aroclors 1254 and 1260 at conc > RA and PCB-118 at conc ~ to RA	8 DET, MFD = beta-BHC	7 DET, MFD = 2,3,7,8-TCDF at conc ~ RA

Exhibit 11-44 (cont'd) Sitewide Summary of Biota Tissue Data, Groups 2A to 4B

Biota Group	Metals	SVOCs/ PAHs	PCBs	Pesticides	Dioxins/Furans
4A Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	4 DET, MFD = benzaldehyde. Only 1 SVOC detected in RA	MFD = Aroclors 1254 and 1260 (only 1254 DET in RA) and PCB-118 at conc > RA	Few DET at FD<50%, MFD = DDE and beta-BHC	FD ~ RA, but at conc > RA
4B Fish	MFD = As, Cr, Cu, Hg, Ni, Zn, in general at conc ~ RA	Several DET, MFD = benzaldehyde, BEHP, and diethylphthalate	MFD = Aroclors 1254 and 1260 at FD and conc ~ RA and PCB-118 at conc > RA	Few DET at low FD and conc, MFD = beta-BHC, pesticides ND in RA	10 DET, MFD = 2,3,7,8-TCDF at conc > RA

MFD = Most frequently detected "X", DET = Number of analytes detected, RA = reference area
Conc = concentrations, FD = frequency of detection, < = less than,
> = greater than, >> = much greater than, and ~ = Similar to

In summary, only relatively minor differences are observed in the COPCs concentrations in tissues taken from the AOCs and the reference area for the migratory or mobile biota. Therefore, area-specific data for these more mobile organisms are unlikely to provide useful information with regard to the identification of source areas or areas in need of remediation. Instead, area-specific data are best evaluated for less mobile organisms, primarily biota from Groups 1, 1A, and 1B. These data are summarized below.

AOC-Specific Results for Biota Groups 1, 1A, and 1B

The results summarized in this section are based on sedentary or less mobile organisms. These organisms, especially the invertebrates in Groups 1A and 1B, have more constant and direct contact with potentially contaminated sediments. Tissue COPCs concentrations for these organisms are therefore more likely to be better linked to sediment quality, as indicated by COPCs concentrations. Because the sediment quality and tissue COPCs concentrations have direct association, these data are presented on a by-area as well as a by-COPCs and by-biota group basis.

As shown in the summary presented below (Exhibit 11-45), there are some important findings based on location-specific data. Results for Group 1 sedentary fish reveal several locations where the frequency of detection and/or the mean concentration of metals COPCs exceed that of the reference area. This is true for Lower Calcasieu, Bayou d'Inde, and Upper Calcasieu. The most important finding within this group is the high mean concentration of mercury in Upper Calcasieu relative to the mean for the reference area. A second important finding is revealed by the comparison of the number of dioxin/furan compounds detected in each area. Twenty-one of these compounds were found in Lower Calcasieu while 25 and 18 were detected in the Bayou d'Inde and Upper Calcasieu, respectively. In contrast, only six dioxin/furan compounds were detected in the reference area. Comparisons of location-specific data for SVOCs/PAHs, PCBs, and pesticides reveal only relatively minor differences between reference area results and results from other AOCs.

Exhibit 11-45 Site-wide Summary of Biota Tissue Data, Groups 1, 1A, and 1B

Biota Group	Areas of Concern	Metals	SVOCs/ PAHs	PCBs	Pesticides	Dioxins/ Furans
1 Fish	LC	FD>RA (Ni) Conc>RA (Hg, Se, Zn)	9 DET, MFD = benzaldehyde (FD and conc<RA) and phenol. HCBD DET but not in RA.	Aroclor 1254 (FD~RA, conc<RA) and 18 congeners (FD and conc ~RA) DET.	endosulfan sulfate DET but not in RA. None DET in LC also found in RA.	21 DET, MFD = 2,3,7,8-TCDF.
	BI	FD>RA (As, Cr, Cu, Pb, Hg, Ni, Se, Zn). Conc >RA (Cr, Cu, Pb, Hg, Se, Zn).	9 SVOCs/1 PAH DET. Benzaldehyde MFD, but conc <RA.	Aroclor 1254 and 19 congeners DET. Aroclor 1254 FD >>RA, conc > RA. Congeners FD~RA.	3 DET at low FD and conc.	25 DET. Of 6 also DET in RA, FD~RA, conc >RA.
	UC	FD>RA (none), conc >RA (As, Pb, Zn). Mean conc Hg 2X RA mean.	5 SVOCs DET, MFD = 2- and 4-methylphenol (neither DET in RA). Phenol FD and conc>RA	Aroclor 1254 only Aroclor DET, at conc>RA. MFD congener = PCB-118, conc of congeners <RA	Not Detected	18 DET at low FD and conc. MFD=2,3,7,8-TCDF (mean=0.307 pg/g), ~RA
	RA	Similar elements DET	See above	See above	Few DET	6 DET
1A Bivalves	LC	FD >RA (none), conc >RA (Cu, Se, Zn).	3 SVOCs/3 PAHs DET. MFD = benzaldehyde and BAP	No Aroclors DET. MFD congener = PCB-118.	Not Detected	21 DET, FD~RA, conc>RA
	BI	FD>RA (none), conc >RA(Cu, Hg, mHg, Ni, Se, Zn).	1 SVOC/18 PAHs DET	Aroclor 1254 and 1260 DET, MFD congener = PCB-118. Congener FD~RA, conc >RA.	12 DET, MFD = beta-BHC. None DET in BI were DET in RA.	24 DET, FD~RA, mean conc >RA.
	UC	MFD=As, Cr, Cu, Hg, mHg, Ni, Se, Zn	5 SVOCs/18 PAHs DET, MFD = BAP (mean=1.066 ug/Kg)	Aroclors 1254 and 1260 FD<10%. Congeners not analyzed	14 DET, MFD=DDE (max=2.7 ug/Kg)	13 DET, compounds ~ RA
	RA	No sample collected	NS	6 DET	4 DET	11 DET
1B Crustaceans	LC	DET = Cu, Pb, Hg, Se, Zn.	Not Detected	Not Detected	3 DET	Not Analyzed
	BI	MFD = As, Cu, Pb, Hg, Ni.	No SVOCs DET, 18 PAHs DET	Aroclors 1254 and 1260 DET, MFD congener = PCB-129.	12 DET, MFD = beta-BHC.	34 DET, MFD = 2,3,7,8-TCDF.

	UC	MFD = As, Cu, Hg, Ni	No SVOCs, 18 PAHs	Aroclor 1254 and 1260, No congeners analyzed	3 DET	13 DET
	RA	NS	NS	NS	NS	NS

MFD = Most frequently detected analytes detected
Upper Calcasieu
FD = frequency of detection
> = greater than

LC = Lower Calcasieu
BI = Bayou d'Inde
Conc = concentrations
NS = Not sampled
>> = much greater than

"X" DET = Number of
RA = reference areaUC =
RA = reference area
< = less than
~ = similar to

Biota-Sediment Relationships for Group 1A Biota
Geometric mean biota-sediment relationships for Group 1A shellfish (Bayou d'Inde and Upper and Lower Calcasieu) and Group 2A crustaceans (reference area), expressed as BSAFs rounded in most cases to two significant digits, are presented for each area in Appendix H. The ranges of these BSAFs are presented below for each class of COPCs (e.g., metals, PAHs) or for an individual PAH where only one PAH was detected in both sediment and biota. The number of samples refers to paired (co-located) samples of both sediment and biota. Appendix H presents all COPCs-specific and AOC-specific BSAFs for Group 1A biota based by sample.

Lower Calcasieu (Group 1A shellfish - one sample)
Geometric mean BSAFs for metals other than mercury range from 0.0006 (lead) to 1.5 (zinc). Geometric mean BSAFs for mercury and methyl mercury are 0.013 and 0.4, respectively. Geometric mean BSAFs for PAHs range from 0.0023 (benzo(k)fluoranthene) to 0.0045 (benzo(a)pyrene).

Bayou d'Inde (Group 1A shellfish - one sample)
Geometric mean BSAFs for metals other than mercury range from 0.0002 (lead) to 0.05 (cadmium). Geometric mean BSAFs for mercury and methyl mercury are 0.060 and 9.3, respectively. The geometric mean BSAF for phenanthrene is 0.098.

Upper Calcasieu (Group 1A shellfish - 5 samples)
Geometric mean BSAFs for metals other than mercury range from 0.0056 (lead) to 1.0 (silver). Geometric mean BSAFs for mercury range from 0.007 to 0.28 in the five samples. Geometric mean BSAFs for PAHs range from 0.01 (benzo(a)pyrene and indeno(1,2,3-cd)pyrene) to 0.06 (anthracene).

Reference area (Group 2A crustaceans - one sample)
Group 1A shellfish were not sampled in the reference area. Data on Group 2A crustaceans, which are more mobile than Group 1A shellfish, are used to generally describe the sediment/biota relationships within the reference area. PAHs were not detected in the reference area. Geometric mean BSAFs for metals other than mercury range from 0.02 (lead) to 1.09 (cadmium). The geometric mean BSAF for mercury is 0.105. These data probably do not describe the sediment/biota relationships as well as the data based on Group 1A shellfish because of crustacean mobility. However, most of the Group 2A crustaceans sampled in the reference area are not expected to range widely over the estuary and are in fact likely to remain within the described reference

area. These biota are therefore considered reasonable representatives of benthic biota having direct contact with reference area sediments.

BSAF Summary

COPCs that are easily bioaccumulated and not easily or rapidly depurated are expected to accumulate to the highest concentrations in exposed biota. Such COPCs include mercury and, for Group 1A bivalves, PAHs. Mercury can be converted to methyl mercury in sediment and in biological tissues, so mercury BSAFs can be viewed somewhat similarly to methyl mercury BSAFs. It is noted, however, that methyl mercury is more rapidly accumulated and accumulates to a higher degree than inorganic mercury. The highest overall BSAF was determined for methyl mercury in Bayou d'Inde (9.3). With a very few exceptions, geometric mean BSAFs for most other metals remained below 1.0. In most cases, the lowest geometric mean BSAFs were for lead, which is not unexpected given the low solubility and bioavailability of lead in sediments. BSAFs for PAHs generally remained low, in all cases less than 0.1. Other than the single high geometric mean BSAF for methyl mercury in Bayou d'Inde (9.3), the BSAFs determined for this site appear to be similar to those determined for other contaminated sites where BSAFs commonly approximate unity (1.0) for most COPCs.

The BSAFs presented here can be used to evaluate in a general sense the bioavailability of site COPCs. The identification of COPCs that occur in forms that are accumulated in biological tissues is reflected in the BSAF data presented. Also, these BSAFs can be used as input parameters to food chain modeling to derive predicted COPCs doses via ingestion of food items. This use is relevant only if it is determined that food chain modeling is indicated for this site.